UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 207

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. PROFESSIONAL PAPER July 17, 1915.

THE CYPRESS AND JUNIPER TREES OF THE ROCKY MOUNTAIN REGION

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By

GEORGE B. SUDWORTH, Dendrologist

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SCOPE OF THE BULLETIN.

This bulletin describes the distinguishing characters, geographic distribution, and forest habits of all the known species of cypress (Cupressus) and juniper (Juniperus) growing within the Rocky Mountain region. The region embraces western North and South Dakota, Montana, Idaho, Wyoming, western Nebraska, Colorado, Utah, Nevada, Arizona, New Mexico, and western Texas. Such outlying regions as the Dakotas, western Nebraska, and western Texas are included because a few species extend from the main Rocky Mountain region into them. For the same reason Canadian territory lying directly north of the Rockies and Mexican territory adjacent to our Southwest are also included. Canada has no cypress or juniper trees that do not occur at some point within the United States. Mexico, on the other hand, has both cypress and juniper trees that

are not found anywhere in this country. Such species, however, are not considered in the present bulletin.

So far as possible the use of technical descriptive terms has been avoided, and only such distinguishing characters (color, texture, etc.) are defined as can not be shown clearly in a black and white drawing. The illustrations represent foliage, fruits, seeds, and other important parts of the trees in their natural size, so that the element of size, so often distinctive, as well as the form in the specimen studied, can be easily compared with the drawing. To insure accuracy in details practically all of the illustrations are line drawings of photographs.

The maps showing the geographical distribution [1] of the different species are photographic reductions of the large folio sheets upon which the distribution data were originally platted, thus affording a more accurate outline of range than is apparent from the small size of the map. These data include all the published and unpublished information now available in the Forest Service.[2] The greater part comprises field notes and unrecorded observations and reports of Forest Service officials who, in the exploration and administration of the National Forests, have special opportunities for gathering such data.

Additional information was obtained from field notes accompanying specimens preserved in the forest herbaria of the Forest Service and the National Museum, Washington, D. C., while through the courtesy of officials in charge similar information was gathered from the Arnold Arboretum, Jamaica Plain, Mass., the Field Museum of Natural History, Chicago, Ill., and the University of Nebraska, Lincoln, Nebr. Field notes, forest photographs, and specimens collected by members of the Bureau of the Biological Survey have also contributed new and valuable range data.[3]

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[1] Only the botanical range is shown, it being impracticable to combine with this the commercial range of timber-producing species, the supplies of which are constantly reduced by lumbering operations.

[2] The Mexican range of cypresses and junipers is so imperfectly known at present that but few authentic locations are given for them in that region. These locations are shown by small circles of solid color. Further provisional range of these trees in Mexico is indicated by short parallel lines and is based only on reports which have not been verified.

[3] Grateful acknowledgment is made in this connection to Dr. C. Hart Merriam, formerly chief of the Bureau of Biological Survey; to Dr. H. W. Henshaw, present chief of that bureau, and to Dr. A. K. Fisher, Chief of the Division of Economic Ornithology; also to Messrs. Vernon Bailey and H. C. Oberholser, members of the same bureau. To Prof. Charles S. Sargent, director of the Arnold Arboretum, and to Prof. J. G. Jack of the same institution, the author desires especially to acknowledge his hearty appreciation for the loan of herbarium specimens and other helpful courtesies. The writer's cordial thanks are here expressed to Dr. Charles E. Bessey (now deceased), of the University of Nebraska, and to Dr. C. F. Millspaugh, of the Field Museum of Natural History, for the privilege of compiling range data from the herbaria in their departments. For helpful information regarding junipers in Texas acknowledgment is made to Prof. William L. Bray, now of the University of Syracuse, N. Y. Acknowledgment is due also to Mary C. Gannett for the compilation and preliminary mapping of a part of the range data, and to W. H. Lamb and Georgia E. Wharton, of the Section of Forest Distribution, who revised and completed this compilation and prepared final copies of the distribution maps. Finally, the writer wishes to express his grateful appreciation of the assistance received in various ways from Forest officers and other members of the Forest Service.

Naturally the ranges of the better known and more useful trees are more complete than those of the smaller, relatively unimportant ones. Altogether, however, our present knowledge of the geographic distribution of Rocky Mountain cypresses and junipers is still incomplete. It is hoped, therefore, that the publication of range data now available will stimulate the collection of further information.

A key for the identification of junipers is provided on page 36. One for the cypresses is deemed unnecessary, because the two species considered are so strikingly different that they can be quickly identified by consulting the descriptions.

In this connection the writer wishes to say that trees, as is the case with other plants, can be satisfactorily identified only by first becoming familiar with the character and appearance of their foliage, flowers, fruits, bark of the trunk and branches, wood, and habit of growth. Knowledge also of their natural habitat and associates is helpful and an essential part of the life history. Naturally such information can be obtained best by studying trees where they grow. Representative specimens of the different parts of the tree are useful for further study, and should be collected whenever possible. Merely a few sprigs hastily taken in passing a tree will not be a sufficient means of determining and knowing the species.

CLASS AND FAMILY RELATIONSHIP OF CYPRESSES AND JUNIPERS.

The cypresses and junipers belong to a class of plants technically known as Gymnosperms, which are distinguished by their resinous wood and in the fact that their ovules (destined to become seeds) are borne naked or without the usual covering peculiar to the other great class of seed-bearing trees called Angiosperms. Familiar examples of the Gymnosperms are the pines, spruces, firs, etc., while the Angiosperms include the oaks, walnuts, hickories, etc., which do not have resinous wood. Gymnosperms produce wood which is formed in concentric layers or rings of growth, one ring being laid on each year and outside of the preceding one and just beneath the bark. The age of Gymnosperms can, therefore, be accurately told by counting the rings shown on a cross section of the stem cut off at the ground just above where the root is given off.

According to the character of their fruits, Gymnosperms are divided into two families—(1) Coniferæ, trees which bear cone fruits (pines, etc.), and (2) Taxaceæ, trees which bear an olivelike fruit (the seed inclosed in a fleshy sack), as in the yew trees.

Because their fruits are true cones, cypress and juniper trees belong to the family Coniferæ. Other generic groups of this family are the pines (Pinus), spruces (Picea), larches or true tamaracks (Larix), hemlocks (Tsuga), false or bastard hemlocks (Pseudotsuga), firs or

"balsam trees" (Abies), "bald," or deciduous-leafed cypress (Taxodium), arborvitæs or "cedars" (Thuja), and redwood and bigtree (Sequoia). All of these trees except the junipers bear a fruit which is a distinctly woody cone, with from two to several naked seeds under each of its overlapping or otherwise closely joined scales. The junipers, however, produce a berrylike fruit, which, though not woody, is, nevertheless, morphologically a cone, the external resemblance to a berry being due to the joining of its fleshy cone scales. The seeds of most conifers have a thin wing, which helps them greatly to be scattered by the wind far from the parent trees, thus providing for their rapid reproduction over a wide area. On the other hand, seeds of some conifers have no wings or merely rudimentary ones, which do not materially aid in distributing the seeds, this being accomplished through the agency of flood waters and animals. Junipers are examples of this class, their wingless seeds and the berrylike fruits containing them being largely dependent for their distribution upon birds, which eat them for the fleshy outside pulp,[1] and upon flood waters, which carry them away from the parent trees.

The leaves of some conifers are scalelike and very small, as in the case of leaves that clothe the twigs of junipers, cedars, and cypresses, while the leaves of all other conifers are needlelike and long, as in the case of the leaves that clothe the twigs and branches of pines, spruces, etc. Of our conifers, all but the bald cypress (Taxodium) and larches (Larix) have leaves that remain green and adhere to the trees for several years, a feature which has given them the popular name of "evergreens." The number of seed-leaves[2] (cotyledons) produced by conifers varies from 2 to about 18.

GENERIC CHARACTERISTICS OF CYPRESSES.

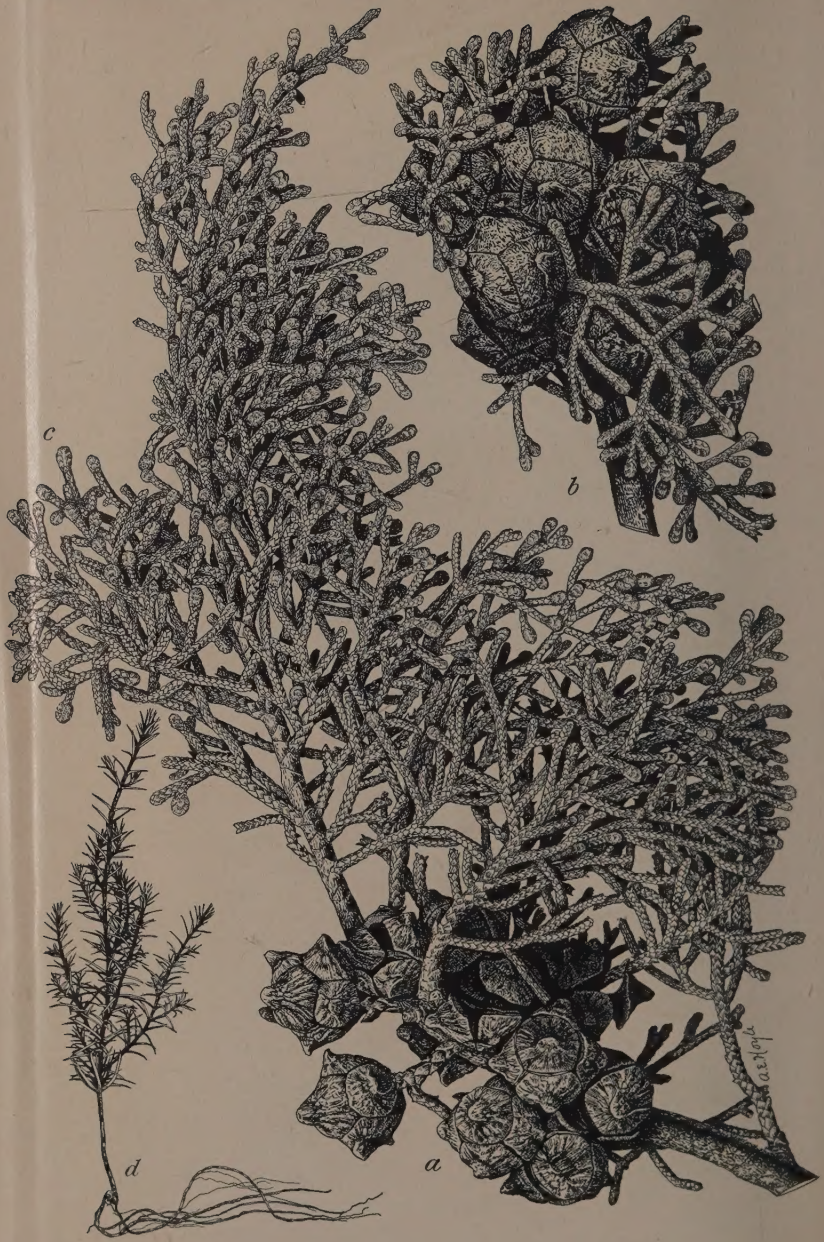
The term "cypress" is popularly applied to three distinct generic groups of North American trees: Taxodium, of the southeastern States; Chamæcyparis, represented in the South Atlantic and Pacific coast forests; and Cupressus, of which native species are found in the southern Rocky Mountain and Pacific coast regions. Strictly speaking, the name cypress should be applied only to the trees of the genera Chamæcyparis and Cupressus, both of which are closely related. Species of Cupressus differ from those of Chamæcyparis in having quadrangular twigs instead of flat ones, and sprays arranged not in one plane but irregularly (Pls. II and V).[3] The overlapping, minute, scalelike leaves of the trees of both groups are arranged in alternately opposite pairs, but those of Cupressus are minutely toothed on their

[1] The hard seeds of the junipers lose none of their germinative vitality by passing through the digestive organs of birds.

[2] Seed-leaves are the first foliar organs appearing above ground when the seeds germinate.

[3] Compare these with figures 65, 66, and 67 in "Forest Trees of the Pacific Slope."

CUPRESSUS ARIZONICA: FOLIAGE AND CLOSED CONES.



CUPRESSUS ARIZONICA.

a, *b*, Different forms of old cones; *c*, male flower buds (in autumn); *d*, seedling three months old (one-half natural size).

margins, while in Chamæcyparis the margins of the leaves are entire or smooth. In Cupressus the leaves of each season's growth remain on the trees from three to four years. The minute flowers, which appear in early spring on the ends of the twigs, are inconspicuous, especially the female flowers. The male flowers, which bear pollen only, and the female flowers, which produce cones and seeds, are borne on different twigs of the same tree. The cones mature at the end of the second season,[1] and bear about 15 or 20 seeds under each fertile cone scale, instead of only 4 or 5 seeds, as in the case of Chamæcyparis. Seeds of native Cupressus differ fundamentally from those of Chamæcyparis in being without thin, membranous wings. The cones of Cupressus are strongly attached to the branches and remain on the trees for a great many years, while those of Chamæcyparis are lightly attached to the twigs and usually fall from the trees within one or two seasons. Seed-leaves of Cupressus are from 3 to 5, and in Chamæcyparis only 2.

The strongly aromatic wood of Cupressus is remarkably durable, but the small size and poor timber form of most native species make it of little commercial value. As forest trees, these cypresses are of considerable importance in assisting to form a protective cover on wind-swept, sandy coasts or dry, arid slopes and in sparsely wooded canyons.

Six species of Cupressus are found in the United States. Four of these are confined to California, while the other two occur in the southern Rocky Mountain region, one extending into Mexico. Trees of this genus are of ancient origin, representatives, now extinct, once growing in Greenland and western Europe.

ARIZONA CYPRESS.

Cupressus arizonica Greene.

COMMON NAME AND EARLY HISTORY.

This little known species has no accepted distinctive common name. Usually it is called "cypress" by the few who know the tree in its mountain habitat, though its occurrence sometimes in moist situations or near streams has earned for it the local name of "water cypress" or "water cedar." The name "Arizona cypress," based on the technical name, is suggested as appropriate because the tree first became known to botanists and foresters through its discovery in southeastern Arizona, where, in 1880, Dr. Edward L. Greene found it "on the mountains back of Clifton, in the extreme eastern part of

[1] Until quite recently this was believed to be another distinction between Cupressus and Chamæcyparis, the latter being thought without exception to mature their fruit in one season. The fruiting habit of Chamæcyparis nootkatensis is now known to be biennial. See Martin W. Gorman, in Nineteenth Annual Report, U. S. Geological Survey, Part V, 339, 1899; Elwes and Henry, Trees of Great Britain and Ireland, V, 1194, 1910; Sudworth, in Review of Forest Service Investigations, II, 7, Pl. I, 1913.

Graham County." Dr. Greene named and described this species in 1882. Later Dr. Rusby discovered an abundant growth of it in canyons on the north slopes of the San Francisco Mountains, central Arizona.[1]

DISTINGUISHING CHARACTERISTICS.

Trees growing in the most favorable situations have narrow, sharply conical crowns with large horizontal branches, straight, rather rapidly tapering trunks, and long slender leaders, characteristics which distinguish the species at a distance from other associated trees. Such trees are from 50 to 80 feet in height, with from 20 to 30 or more feet of clear trunk. Young trees of this type are particularly straight, with very sharp, pointed crowns and horizontal branches. Trees in exposed and otherwise unfavorable situations develop broad, rounded or flat crowns, and seldom reach a height of more than 25 or 30 feet, with very little clear stem. Diameter growth of Arizona cypress varies from 14 inches to nearly 4 feet. (Pl. III, right.)

The trunk bark of large trees is from 1¼ to 1½ inches thick, and of small ones from one-half to three-fourths of an inch. In color the bark is a dull, ashy brown on the outside and pale to dark cinnamon-brown when broken. It is firm, somewhat fibrous, and sharply and deeply furrowed, the main narrow, flat, continuous ridges being connected with small lateral ones. Bark on the branches, twigs, and very young trunks is loosely scaly, the fresh smooth bark beneath the scales being reddish to a dark yellowish-brown. The minute, scale-like, sharp-pointed leaves (Pl. I) have a whitish bloom, which gives the foliage a pale silvery hue, especially pronounced in young trees. The leaves are mainly without pits on the back; very rarely with resinous glands, which when they do occur are exceedingly small. This latter feature and the general absence of pits distinguish the foliage of Arizona cypress from that of smooth cypress (*Cupressus glabra*), which is commonly marked with large glandular pits. Bruised twigs and foliage of Arizona cypress exhale a strong polecat-like odor, while the trees themselves give off an odor which sometimes can be detected at a distance of 100 yards.

Mature cones of Arizona cypress (Pl. I, *b*), which ripen by September of the second season, vary in diameter from seven-eighths of an inch to an inch, and remain on the trees for many years (Pl. II, *a*, *b*), changing with age and exposure from a dark umber-brown to ashy gray. The conspicuous bosses, or protuberances, of the cone scales are usually small and almost pricklelike on cones just matured

[1] Cupressus arizonica was introduced into England, France, and Germany about 32 years ago, where, according to Elwes and Henry (Trees of Great Britain and Ireland, Vol. V, 1184, 1185, 1910), it grows thriftily and has reached a height of from 15 to about 30 feet.

(Pl. I, *a*, *b*), and larger [1] and hornlike on the older fruit (Pl. II, *a*). The deep purplish-brown seeds (Pl. I, *c*) are somewhat triangular in form and irregular in size, but usually about one-eighth of an inch long. The seed-leaves are from 3 to 5 (Pl. II, *d*, lowermost long leaves).

The heartwood of Arizona cypress is a very light brownish-yellow, and the sapwood a pale straw-color. It is moderately soft and of light weight, narrow-ringed and straight-grained, splitting easily. Dry, freshly cut wood has a slight cedarlike odor. When thoroughly seasoned it is fairly durable in contact with the soil, but is used only to a limited extent in supplying local demands for shakes, posts, corral poles, and rough house logs, because the available supply is small and difficult to obtain. The best grades, however, are suitable for sash, doors, blinds, and other building purposes. The lumber seasons well and is readily held in place.

OCCURRENCE AND HABITS.

Arizona cypress grows in moist or rather dry, rocky, shaly, or gravelly soils on mountain slopes, and in the bottoms and on the sides of canyons, at elevations between 4,500 and 8,000 feet. It is especially fond of moist north-slope gulches and benches where the growth is more dense than in drier situations. For the most part it forms pure or nearly pure stands, quite dense on the more favorable sites. The largest and best formed trees occur on north slopes, in coves, and on benches in protected localities, where the soil is moist, deep, and more permeable, while short stunted trees are found in exposed places where the scanty soil is drier and less permeable. Arizona cypress is occasionally associated with Arizona pine, and at higher elevations with huckleberry oak. In some parts of its range repeated forest fires have destroyed the stand over large areas, so that the tree occurs chiefly in patches and in rather small, isolated bodies.

Seedlings and young trees are apparently able to endure dense shade without having their height growth retarded. Later in life trees may still maintain themselves indefinitely under rather heavy top shade, but in such cases growth in diameter and height is very slow. The lateral branches persist for a long time even in very close stands.

Arizona cypress is a prolific seeder and in some localities bears cones every year. Fresh seed shows a moderately high percentage of germination, but the seedlings are likely to come up tardily at irregular intervals. When seeds remain in unopen cones on living

[1] This appears to be due to the growth of tissue about the base of the bosses after the cone matures, and sometimes also throughout the cone and its stem. Cones of Cupressus macnabiana and Cupressus glabra exhibit the same characteristic. (See "Forest Trees of the Pacific Slope," p. 165.) Dried cones, in which the living, spongy, green tissue has become shrunken, do not show this enlargement as conspicuously as cones recently collected.

trees they may retain their vitality for at least several years.[1] Reproduction takes place abundantly where the exposed mineral soil is moist and not subject to washing by mountain floods. Seedlings are scarce, therefore, on steep, rocky slopes, only appearing where the seed has lodged in pockets and crevices. A small amount of the seed is eaten by rodents.

LONGEVITY.

The exact age attained by Arizona cypress is not at present known, but, judging from the few records available, it is evidently long-lived. Trees from 12 to 38 inches in diameter, in full enjoyment of top light, are from 100 to 310 years old, while suppressed, slow-growing trees from 4½ to 5 inches in diameter may be from 50 to 65 years old. The largest trees known would doubtless prove to be from 375 to 400 years old.

SMOOTH CYPRESS.

Cupressus glabra Sudworth.

COMMON NAME AND EARLY HISTORY.

The first reference to this new and handsome cypress was published in 1895 and was based on the discovery of a grove on Pine Creek at "Natural Bridge," central Arizona, by Prof. J. W. Toumey, who believed the tree to be a form of Arizona cypress.[2] It was not distinguished from the latter tree, however, until February, 1910, when it was named and described[3] from a grove of trees discovered by Mr. Arthur H. Zachau on the north slope of a small tributary stream on the west side of the Verde River Canyon, about 16 miles southeast of the town of Camp Verde, Ariz. This grove covers an area about 6 miles long by 1½ miles wide.[4] In size and development the trees there are fairly representative of the species. In 1910 Mr. Willard Drake reported finding the species on the Coconino National Forest, growing with Arizona cypress, while in the same year Mr. R. L. Rogers observed it in the Coronado National Forest. Recently

[1] No systematic tests have yet been made to determine exactly how long such seeds will retain their germinative vitality. In many cases, however, the author has found perfectly sound seeds in closed cones that have been attached to living trees for eight or nine years. It is probable that still older seeds could be found.

[2] Garden and Forest, VIII, 32, 1895. While Prof. Toumey referred to the Pine Creek trees as C. arizonica, he nevertheless expressed doubt as to their being the same as the Arizona cypress of the Chiricahua Mountains, for he observed that the bark of the Pine Creek trees "peels off in long shreds."

Prof. Toumey's reference to this characteristic of the bark led the writer to suspect the "Natural Bridge" cypress to be the same as the Verde River Canyon tree. Prof. C. S. Sargent has recently examined specimens of Prof. Toumey's "Natural Bridge" tree and finds it to be C. glabra, so that this grove can now be added to the tree's range.

[3] American Forestry, XVI, 88, 1910.

[4] This grove is partly on a ranch belonging to William A. Tinsley, and approximately in township 11 north, range 5 east, where Mr. Zachau saw it first in 1907, and called the writer's attention to the fact that the trees there had very different bark from that of the Arizona cypress, common in the Chiricahua Mountains. Special credit is due Mr. Zachau for this most important observation, which resulted in an investigation of these trees by the writer and in the discovery then that they are of a distinct species.

CUPRESSUS ARIZONICA (RIGHT) WITH CHARACTERISTIC FURROWED BARK, CUPRESSUS GLABRA (LEFT) WITH SMOOTH SCALY BARK.

OF NEWLY RIPENED CLOSED C

size and enlarged twice natural size

Mr. Alfred Rehder detected[1] Cupressus glabra in Oak Creek Canyon, about 20 miles south of Flagstaff, Ariz. In the same year Mr. R. D. Forbes found this species at various points in the Tonto National Forest, Arizona. Further search is likely to reveal its existence elsewhere in Arizona and possibly also in New Mexico and Mexico.

The name "smooth cypress" is adopted here as descriptive of the tree's most conspicuous characteristic, its smooth, purple-red bark Settlers in the Verde River Canyon knew this tree long before its technical discovery and called it "yew-wood," doubtless because the bark of the trunk resembles that of the western yew (*Taxus brevifolia*).

DISTINGUISHING CHARACTERISTICS.

In general appearance the foliage of smooth cypress resembles that of the Arizona cypress, though the former species can be distinguished from the latter by the compact, narrowly oval, or somewhat pyramidal crown. The branches of smooth cypress, particularly of younger trees, are strongly upright. Old trees grown in the open develop long, lower branches, which from their great weight are less upright than those of trees of the same age in a close stand. In height the trees range from 25 to 30 feet, and in diameter from 10 to 14 inches, though much larger trees probably exist.[2] The trunk is slightly tapering, while the upper portion is sometimes divided into several branches, in this respect differing from the usual undivided stem of Arizona cypress. Only about one-fourth to one-third of the trunk is clear of branches (Pl. III, left).

The most distinctive characteristic of this tree is its thin, smooth, dark purple-red bark. Each season's growth of bark, from one-sixteenth to one-eighth of an inch thick, breaks irregularly into small, curled, scalelike plates, which fall away during the succeeding autumn and winter, leaving the trunk smooth. Vigorous trees shed their bark more rapidly and completely than less thrifty ones. The foliage is a bright blue-green (glaucous). The minute, scalelike, acutely pointed leaves (Pl. IV), about one-sixteenth of an inch long and closely pressed on old sprays, are thickened and keeled on the back, where in practically every case there is a comparatively large resin gland, a characteristic which distinguishes the leaves from those of Arizona cypress. Young shoots bear closely pressed leaves from one-fourth to one-half of an inch long, with very keen and more or less spreading points (Pl. V, *a*). The leaves die during the second year, turn a bright red-brown, and remain on the twigs for about 4 years, after which they are shed slowly, and later these small branches

[1] Reported to the writer in letter by Prof. C. S. Sargent, Nov. 6, 1914.

[2] According to Prof. J. W. Toumey (loc. cit.) some of the trees in the "Natural Bridge" grove (which must now be considered to be C. glabra) are 3 feet in diameter.

become ashy gray. The spherical cones [1] (Pls. IV, V) are borne on stout stems from one-fourth to one-half of an inch long (Pl. IV, *a*), and mature at the end of the second season. In diameter they range from seven-eighths to one-eighth of an inch, and are composed of from 6 to 8 [2] scales, armed with large incurved, somewhat flat-pointed bosses.

The mature cones are smooth, but conspicuously wrinkled, and covered with a deep blue-gray bloom, which when rubbed off reveals a rich dark-brown color beneath. Very old cones (Pl. IV, *a*) are ashy-gray, with bosses much less conspicuous [3] than in newly matured cones (Pl. V). Immature cones of one season's growth are light reddish-brown, with areas of pale-bluish bloom. Mature cones may remain on the trees unopened for from 14 to 18 years, and possibly even longer.[4] The red-brown seeds vary greatly in shape from a rounded to a triangular and somewhat rectangular form, and may be from three-sixteenths to five-sixteenths of an inch long, more often the latter. Each cone contains from about 70 to 112 seeds, the largest number occurring in cones with 8 scales. The large size of the seeds at once distinguishes them from those of Arizona cypress, though in color and form the two are similar. Seed-leaves vary in number from 3 to 4.

The sapwood of smooth cypress is a pale straw-color and the heartwood a very light brownish-yellow. Seasoned wood is hard, rather heavy, strong, and with very narrow rings of growth. As in the case of Arizona cypress, the freshly cut, dry wood has a slightly cedarlike odor, which is less pronounced in green wood. Thoroughly seasoned wood is moderately durable in contact with the soil, fence posts lasting about 20 years, and corral poles 30 to 35 years. Cabins built of the logs 40 years ago are still in a good state of preservation. The small size of the trees and the limited supply have confined the use of the wood mainly to local needs. It has been employed to a limited extent for fence posts, corral poles, and rough house logs, fuel, telephone poles, and mine props.

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[1] Male flower-buds (Pl. V, *a*) were abundant when the trees were seen in late autumn. The writer has had no opportunity for examining trees in the spring, so that female flowers have not been obtained.

[2] Very young cones may have 10 scales, but at maturity 2 of the basal ones become abortive.

[3] Due to the thickening of the tissue through growth after maturity. In the case of Cupressus glabra the formation of green spongy tissue in old cones appears to enlarge or thicken only the main body of the cone-scales without increasing the size of the bosses, while in the case of C. arizonica this growth enlarges the bosses as well as the body of the scales.

[4] No systematic tests have yet been made of the germination of seeds from cones of different ages. A physical test, however, showed the majority of seeds in the oldest cones to be in a perfectly sound and apparently germinable condition. The almost phenomenal preservation of these seeds can be accounted for only by the green state of the cone, which supplies and maintains an equable amount of moisture, and by the presence of a considerable amount of tannin in the woody parts of the cone-scales which probably prevents decay of the seeds.

OCCURRENCE AND HABITS.

In the Verde River Canyon grove smooth cypress grows abundantly in gravelly and shaly soils on benches, gentle slopes, and low ridges at elevations between 3,700 and 5,500 feet. It is best developed in protected watered gulches and on the gentler slopes and benches where the soil is moist. At low elevations it is associated with Pinus monophylla, Pinus edulis, Quercus chrysolepsis, and Rhus laurina, while higher up it forms nearly pure stands.

Little is known at present regarding the light requirements of smooth cypress during its early stages of growth, but in later life, judging from the greater density of its crown, this species should be as tolerant of shade, if not more so, than Arizona cypress.

Smooth cypress is a prolific seeder, usually producing cones every year. The fresh seed shows a moderately high percentage of germination, while the vitality of older seed probably declines rapidly after the fifth year.

LONGEVITY.

The extreme age attained by this species has not yet been determined, but it is probably as long lived as Arizona cypress. The largest trees found so far are at least 200 or 250 years old.

GENERIC CHARACTERISTICS OF JUNIPERS.

The junipers are evergreen trees that in general appearance somewhat resemble the cypresses, though their berrylike fruits at once distinguish them from the latter. The adult foliage of most junipers covers the branchlets closely and consists of short minute scalelike sharp-pointed leaves arranged in groups (whorls) of three or in opposite pairs, each of the latter alternating in position around the stem. In some species all of the adult leaves occur in threes instead of in pairs and are then much longer, needlelike, standing out loosely at regular intervals (Pls. VI, VII). The margins of the leaves are smooth or minutely toothed. The juvenile or primary foliage produced by seedlings and older young plants of the first group of junipers noted is more or less similar in general appearance to adult foliage of the last group mentioned. This primary foliage gradually gives way, however, as the plants grow older to the adult scalelike form of leaves. The close scalelike type of leaves very often have a pit or resinous gland on the back (Pl. XIII). When bruised, the foliage of junipers emits a pungently aromatic odor.

The needlelike seed-leaves of junipers are 2 to 6 in number (Pl. XIX).

The minute inconspicuous flowers of junipers are of two sexes. Male, or pollen-bearing flowers (Pl. XII, *a*), and female flowers, which develop into fruit, are each borne chiefly on different trees, or in the case of some species on the same tree (XXIV, *a*).

The fruits, popularly called "berries," are morphologically cones, the pulpy berrylike covering being made up of the fleshy flower scales which unite as the fruit develops, so as to inclose the hard seeds (1 to 12 in number; Pl. XI). The points of the flower scales usually project from the surface of the fruit. Most of our native junipers mature their fruit in from one to two seasons (two summers and one winter), while one species requires three seasons (two summers and two winters).[1] When ripe, the berries are dark blue, red-brown, or copper colored, and except in the case of one Texas juniper the surface is covered with a whitish bloom, which is easily rubbed off. The pulpy flesh of the berries is slightly juicy or mealy, sweetish, and often strongly aromatic, due to the presence of resin cells. Both birds and mammals, especially the former, eat the berries and thus play a most important part in the dissemination of the seeds.[2] Otherwise their distribution would be exceedingly slow, for the berries are too heavy to be carried far from the mother trees except on washed slopes.

Junipers are further characterized by their narrow-ringed aromatic durable wood, the "heart" portion of which is dull yellow-brown in some species and a clear rose-purple red in others. The trunk bark is rather soft and distinctly stringy, one species only having brittle checkered hard bark (Pl. XX).

Junipers are small or at most only medium-size trees unfit in most cases for saw timber except for some minor purposes, although the wood itself is suitable for general use. It is used largely for fence posts, fuel, especially in localities where no other trees grow. From the forester's standpoint junipers are important because of their ability to grow on dry barren slopes and exposed situations where few if any other trees will thrive.

Twelve tree junipers inhabit the United States, nine of which occur within the Rock Mountain region. Of the other three species, one is confined to California, while two are found only in the eastern United States.

Junipers are of ancient origin, remains of them in Tertiary rocks showing that they inhabited Europe ages ago.

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[1] Prof. John G. Jack was the first to point out that in New England the common dwarf juniper (*Juniperus communis*) requires three seasons for ripening its "berries" (Bot. Gazette, XVIII, 369, Pl. XXXIII. 1893). It is not known whether or not the species has a different habit elsewhere in its wide range.

[2] The hard bony coverings of the seeds are entirely unaffected by digestion except, as is believed, facilitating in some degree their germination.

CUPRESSUS GLABRA: FOLIAGE AND NEWLY RIPENED CLOSED CONES.

a, Male flower buds (in autumn); *b*, new shoot showing large form of leaves.

JUNIPERUS COMMUNIS: STERILE BRANCH.

JUNIPERUS COMMUNIS: FERTILE BRANCH AND RIPE FRUIT.

a, Seeds (natural size and enlarged twice natural size) divested of the pulp.

COMMON JUNIPER.[1]

Juniperus communis Linnæus.

COMMON NAME AND EARLY HISTORY.

The common or dwarf juniper is the most widely distributed tree inhabiting the northern half of the globe.[2] It was technically named and described in 1753, probably from specimens obtained from northern Europe. Apparently, however, it was previously long known in Europe and in Asia. It is difficult to determine when it was first found in North America. The earliest botanical account of it, however, as a native of this country appeared in about 1803. Juniperus communis has a long botanical history in which various forms have been described under about sixteen different specific and varietal names. Thirteen varieties are now distinguished in cultivation, the best marked one being J. communis sibirica. The generally accepted vernacular name of this species, "common juniper," is derived from its technical name. Occasionally it is called "dwarf juniper" and "ground cedar."

DISTINGUISHING CHARACTERISTICS.

Throughout its wide range in North America common juniper attains tree size only in a few counties of southern Illinois, where it grows to a height of from 15 to nearly 25[3] feet and a diameter of from 6 to 8 inches. Elsewhere it is a shrub less than 5 feet high, with numerous slender, half-prostrate stems forming a tangled mass from 5 to 10 feet across. Its very unsymmetrical trunk has conspicuous rounded ridges and intervening grooves at and near the ground. It is clear of branches for only a few feet, and the crown, narrow and very open, has short, slender branches trending upward. The bark, in color a deep chocolate brown tinged with red, is less than one-eighth of an inch thick and composed of loosely attached, extremely thin scales.

The dark, lustrous green, keenly pointed, needlelike, or narrow, lance-shaped leaves (Pls. VI, VII), are chalky white on their upper

[1] The prostrate, high mountain form of this species must be considered a variety, J. communis sibirica (Burgsd.) Rydberg. It differs from J. communis L. in being wholly prostrate, and also in the fact that its foliage is often shorter than that of J. communis.

Another prostrate shrub juniper, more or less common from Maine and New Foundland to Hudson Bay and the eastern slopes of the Rockies in Montana is Juniperus sabina prostrata (Pers.) Loudon. J. sabina, of which this prostrate shrub is held to be a variety, is generally distributed through central and southern Europe and Siberia. It is distinguished from the North American variety by being a strictly upright shrub, or occasionally a small tree. The freshly cut wood and crushed twigs of these plants have a characteristic, rather disagreeable odor. They are further distinguished from J. communis and its variety J. communis sibirica by having the short scalelike, pointed leaves in alternately arranged pairs, the points of the leaves more or less spreading and free. The needlelike leaves of J. communis are arranged in groups of three.

[2] It also grows naturally in northern, central, and eastern Asia, as well as in northern and central Europe.

[3] In Germany and Norway it is said to attain 30 to 40 feet or more in height.

side, a characteristic which clearly distinguishes this juniper from all other native species. The leaves spread widely from the triangular branchlets in groups of three at rather regular intervals, those of each season's growth persisting for five or six years. Young plants of other species, especially of Juniperus virginiana, have sharp-pointed leaves similarly arranged, but much shorter and more slender. Male and female flowers are usually borne on different twigs of the same tree, though sometimes on different trees. The "berries" (Pl. VII) are mature at the end of the third summer, when they are very dark blue, almost black, and coated with whitish bloom. The top of the "berry" is conspicuously marked by three blunt projections, which are points of the ovules (Pl. VII). The soft flesh of the ripe fruit is dry, resinous-aromatic, and sweet, and sometimes contains one, but, commonly, from two to four hard, bony seeds. Birds and mammals eat the berries greedily and thus assist in disseminating the seed; otherwise the fruit may remain on the branches during the following winter or spring, occasionally even until late summer, before falling to the ground.

The heartwood of common juniper is pale, yellowish brown, heavy, rather tough, very narrow-ringed, and exceedingly durable. Even the largest tree form of this juniper known in the United States is too small to be of any commercial value, though the more common shrubby type forms a low, matted ground cover on the highest and most exposed slopes and crests, effectively holding masses of snow until stored water is gradually given up to the soil.

OCCURRENCE AND HABITS.

Common juniper occurs on dry knolls, sandy flats, rocky slopes and ridges, interspersed among spruce and aspen, at elevations between about 2,700 and 10,000 feet.[1] Generally, however, it grows at altitudes between 4,500 and 8,000 feet. It is extremely tolerant of shade, where, however, its growth is very much slower and its foliage less dense than in full light.

Common juniper is a fairly abundant seeder. Seed crops, somewhat larger than the ordinary, occur at irregular intervals of from two to three years. On the whole, reproduction is rather sparse and irregular, due no doubt to the fact that most of the berries are eaten by birds, comparatively few of them reaching the ground in the immediate vicinity of the mother plants, where conditions for germination are most favorable. The fact that berries of this juniper require so long a period to mature may also account in some measure for the lack of natural production.

[1] The vertical range of the common juniper varies enormously throughout its world-wide distribution, from sea level on the Pacific coast to 14,000 feet in the Himalayas.

LONGEVITY.

Small trees from 2 to 4 inches in diameter, such as occur in this country, are from 25 to 33 years old. Records of trees grown in Norway show that one 13 inches in diameter was 114 years old, while another 12½ inches through was 300 years old. Sixteen-inch trees ranged from 130 to 150 years in age, and a 14-inch tree had attained 216 years. Dr. Whittmack[1] speaks of a tree of this species, 4 or 5 feet in diameter at the base, cut in the parish of Kokenberg, in Livland, Sweden, which had reached the extreme age of 2,000 years.

WESTERN JUNIPER.

Juniperus occidentalis Hooker.

COMMON NAME AND EARLY HISTORY.

Throughout its natural range this high mountain species is called "juniper," seldom being distinguished from other juniper trees of the same general region. The name "western juniper," adopted here, is coined from the tree's technical name.

Juniperus occidentalis is only sparingly represented in the Rocky Mountain region, its main range lying in the Pacific States. There appears to be no record of the earliest discovery of this tree, which was probably seen by Lewis and Clark on their expedition to our Northwest in 1804 to 1806, for their route took them through a part of its range. The tree received its present technical name, Juniperus occidentalis Hooker, in 1839. Some of the early writers confused the first specimens collected of mountain red cedar with J. occidentalis, but only three other technical names have been applied to it during the nearly 100 years it has been known to science.

DISTINGUISHING CHARACTERISTICS.

Western juniper has a round-topped, open crown, extending to within from 4 to 8 feet of the ground, and a short, thick, conical trunk. In the Rocky Mountain region its height varies from 15 to 20 feet, or occasionally even to 30 feet. Much taller trees, 60 or more feet high and with diameters sometimes as large as 60 inches, occur in protected situations in the Pacific region.

The short chunky stem is ridged and grooved, but is usually straight, or, in the most exposed sites, sometimes bent and twisted. The tree develops enormously long and large roots, which enable it to withstand the fierce winds of high mountains. Huge lower branches often rise like smaller trunks from the base and middle of the stem. Other branches are large and stiff, standing out straight or trending

[1] Gartenflora, xxxvi, 139, 1887.

upward from the trunk, while there are also many short ones. Sometimes the top is divided into two or three thick forks, giving the tree a broader crown than usual. In such cases, if the trees grow on flats with deep soil, the crowns are dense, symmetrical, round-topped, and conical, and extend down to within 6 feet of the ground. Young trees have straight, sharply tapering stems and narrow, open crowns of distant, slender, but stiff-looking, long, upturned branches. In old age the lower and middle-crown branches often droop, but their tips continue to turn upward. The firm stringy bark of the trunk is a clear, light cinnamon-brown, one-half to 1¼ inches thick, distinctly cut longitudinally by wide, shallow furrows, the long flat ridges being connected at remote intervals by narrower diagonal ones. Bark of branchlets that have recently shed their leaves is smooth, very thin, and clear reddish-brown, but later, as the twigs grow larger, is divided into loosely attached, thin scales of lighter red-brown.

The short, pale ashy-green, scalelike leaves (Pl. VIII) clasp the stiff-looking twigs closely, the longer, sharper leaves of young, thrifty shoots spreading slightly at their points (Pl. VIII, *a*). All leaves have a prominent, glandular pit on the back, the abundant whitish resin of which marks the twigs conspicuously and is a distinguishing character. The leaves are arranged on the stems in successive groups of three, thus forming rounded twigs with six longitudinal rows of leaves. The margins of the leaves are minutely toothed. Those produced each season die in about their second year.

Male and female flowers are borne on different trees. The "berries" (Pl. VIII), from one-fourth to one-third of an inch in diameter, mature about the first of September of the second year, when they are bluish black with a whitish bloom. The skin is tough, and only slightly marked at or near the top of the berry by the tips of the female flower scales. The sweetish, pungent aromatic flesh of the ripe berries is scanty, dry, and contains from two to three bony, pitted, and grooved seeds (Pl. VIII, *b*, *c*, *d*). Seed-leaves, two in number, are needlelike, sharp pointed, and about an inch long. Seedling leaves are similar in form, but much shorter, spreading in groups of three at close intervals. The leaves produced in subsequent years are successively shorter and closer in their arrangement, until about the third or fourth year, when a few twigs bear leaves of adult form.

The wood of western juniper is pale brown, tinged with red, with a slight aromatic odor, very narrow-ringed, and, like that of the other brown-wooded junipers, remarkably durable. It is soft and brittle, and splits easily, in this respect resembling the wood of the eastern red-wooded pencil cedars (*J. virginiana* and *J. barbadensis*). The short, often very knotty trunks, are much used locally for posts and fuel, but furnish poor saw timber, though they would give good blocks for pencils.

JUNIPERUS OCCIDENTALIS: FOLIAGE AND RIPE FRUIT.

a, New shoot showing large form of leaves; *b*, *c*, *d*, showing variable number of seeds (natural size and enlarged twice natural size) divested of pulp.

JUNIPERUS SCOPULORUM: FOLIAGE AND RIPE FRUIT FROM TREE IN PROTECTED SITE.

a, *b*, Variable number of seeds in different berries (natural size and enlarged twice natural size).

JUNIPERUS SCOPULORUM: FOLIAGE AND RIPE FRUIT FROM TREE IN EXPOSED SITE.

OCCURRENCE AND HABITS.

Western juniper grows on exposed high mountain slopes and sides of canyons, in dry gravelly and rocky soils, and sometimes in crevices of bare rocks. In the Rockies[1] it is found generally at elevations between 2,000 and 9,000 feet, though most often between 6,000 to 8,000 feet, where the best growth occurs. It usually forms very open but practically pure stands, and is sometimes scattered among other trees of its high range. As a rule, pure stands are limited to from a few to 40 or 50 acres. Western juniper is forestrally important because it thrives at high elevations, in dry wind-swept situations, where few other trees can exist. It always grows in the full enjoyment of light, and appears to be decidedly intolerant of shade. Even seedlings in partial shade are much less vigorous than young plants growing in full light.

Western juniper produces its fruit abundantly, yet the seedlings are always much scattered and occur only in pure mineral soil. As in the case of other junipers many of the berries are eaten by birds, which assists in distributing the seed; but very tardy germination of the seed under the particularly unfavorable conditions within the tree's habitat, as well as the fact that seedlings can not grow in better soil under the shade of other trees, probably accounts for the sparse reproduction.

LONGEVITY.

While the extreme age this tree may attain is not yet fully determined, it is known to be exceedingly long-lived. Both height and diameter growth are slow when the tree is rooted in crevices of rock and exposed, as it usually is, to fierce winds. Even in such situations, however, it grows persistently, producing a trunk that is out of all proportion in thickness to its height. The wood of such trees is very narrow-ringed (one-sixth to one-tenth of an inch), indicating great age. In protected mountain coves and on flats with deep washes of loose earth, diameter growth is more rapid and the annual rings wider. Trees of this type, from 20 to 48 inches in diameter, are from 125 to 300 years old, while in general the age of full-grown trees is estimated to be between 500 and 700 years. The largest trees grown in exposed places are probably from 800 to 1,000 or more years old.

[1] Elsewhere in its range this juniper has a widely varying vertical distribution from 600 to about 10,500 feet, the highest elevation attained being in the California Sierras. Its commonest occurrence there is at elevations between 6,000 and 9,000 feet.

MOUNTAIN RED CEDAR.

Juniperus scopulorum Sargent.

COMMON NAME AND EARLY HISTORY.

Mountain red cedar was for a long time supposed to be a western form of the red cedar (*Juniperus virginiana*) of northeastern United States. The two species resemble each other in the general appearance of their foliage and fruit and especially in the dark purple-red color of their heartwood, but the mountain red cedar differs fundamentally from the eastern cedar in that its berries require two seasons to mature, while those of the latter species mature in one.

Mountain red cedar was first discovered in 1804 [1] by Lewis and Clark while on their memorable expedition [2] across this continent. The first technical name applied to the tree is Juniperus excelsa Pursh,[3] which was published in 1814. From 1838 to 1897 other authors referred to this tree mainly as J. virginiana and sometimes as J. occidentalis, while specimens shown at the Centennial Exposition in 1876 were described as J. virginiana var. montana Vasey.[4] Prof. C. S. Sargent [5] distinguished the tree from J. virginiana in 1897 and named it J. scopulorum. A noteworthy fact is, however, that in 1876 Dr. George Vasey, the first botanist of the United States Department of Agriculture, gave to this tree the distinct common name "Rocky Mountain red cedar," [6] and also pointed out the fundamental differences between its crown form and the eastern red cedar. His recognition of these distinctions would seem to show that Dr. Vasey was really the first author to separate this tree from its eastern relative and but for his unfortunate use of a preoccupied name ("var. *montana*") Dr. Vasey's name for the tree probably could now be maintained.

DISTINGUISHING CHARACTERISTICS.

In open, exposed situations mountain red cedar is somewhat bushy and from 10 to 20 feet high, with a short trunk from 6 to 10 inches in diameter, and a rather narrow, rounded crown of large, long limbs trending upward. Often the very short trunk is divided into several stems. In sheltered canyons and other protected places, however, the trunk is straight and sharply tapered, while the tree has an open, slender-branched crown, and attains a height of from 25 to 30 or more feet and a diameter of from 12 to 30 inches. In this form the

[1] Fide Sargent, Silva, XIV, 94, 1902.

[2] History of Expedition under Command of Lewis and Clark, ii, 457 (ed. Coues).

[3] This name is unavailable for the mountain red cedar, because Bieberstein applied it to an Asiatic juniper in 1800.

[4] A name preoccupied by Aiton, who in 1789 applied it to a form of the common juniper (*Juniperus communis*), thus making it unavailable for the Rocky Mountain tree.

[5] Garden and Forest X, 420, fig. 54, 1897.

[6] Report U. S. Dept. Agr. 1875, 185, 1876.

ends of the branches and twigs are often so drooping, or even pendent, that the tree is locally called "weeping juniper." The somewhat stringy bark, shallowly cut into a network of narrow seams and ridges, is grayish on the outside and red-brown within.

The minute, scalelike, pointed, often long-pointed, leaves (Pls. IX, X) cover the slender four-sided twigs in four rows of alternately opposite pairs. The back of each leaf usually has a long, indistinct pit (gland). The margins of the leaves are smooth. The foliage varies in color from a dark to a light green, the latter shade being emphasized by a whitish bloom.

Male and female flowers are borne on different trees. The mature berries (Pls. IX, X) are smooth, and clear blue in color, due to a whitish bloom over the blackish skin. They usually contain 2 seeds, but sometimes 3, and occasionally 1, in a sweetish, resinous pulp. The seeds (Pl. IX, *a*, *b*) are pointed at the top ends, conspicuously grooved, and marked at the base with a short two-parted scar (hilum). The number and character of the seed-leaves are at present unknown.

The wood of mountain red cedar is a dull red, or more often rather bright rose-red, with irregularly disposed yellowish-white streaks. It is narrow-ringed and has a thick layer of white sapwood. Just how durable the heartwood may be is not known, though fence posts made from it are known to have been in a good state of preservation after 20 years of service. It is likely that well-seasoned posts of mountain red cedar would be as durable as those of eastern red cedar, which may remain sound in contact with the soil for 30 or 40 years. The color, "grain," working qualities, and structure of the two woods are very similar. Mountain red cedar is adapted to the same uses to which eastern red cedar is put, but except in a few parts of its range the supply is rather scarce and scattered. The tree is desirable for planting within its natural range, since it thrives on dry soil and produces wood suitable for pencils.

OCCURRENCE AND HABITS.

Mountain red cedar grows on dry, exposed mesas, low, dry mountain slopes, and in rather moist canyon bottoms (where it reaches its best development), in rocky, sandy, or gravelly soils, though seldom in the latter. Within our Rocky Mountain region it occurs at elevations between about 5,000 and 9,000 feet, the lowest elevation being characteristic of the northern distribution, and the highest of its central and southern range. It is most commonly found between 5,000 and 7,000 feet, and is rather rare above 8,000 feet.[1]

Single trees or small groups are usually scattered among piñon pine, one-seed juniper, mountain mahogany, gambel oak, and narrow-leaf cottonwood. Sometimes it is associated with Douglas fir, Engelmann

[1] In its Pacific slope range this species occurs sometimes from sea level to about 3,200 feet.

spruce, and western yellow pine, while small, practically pure stands are occasionally interspersed with pure stands of piñon pine.

The exact light requirements of mountain red cedar are as yet imperfectly known. It endures rather dense shade during the seedling and early sapling stages in moist, cool situations. Later, however, it seems to require top light for height growth, because in close, pure stands and under the dense side shade of other species the trunk branches die. It develops a distinctly thinner and more open crown in protected and shaded situations than in full light. While in early life it has about the same degree of tolerance as eastern red cedar, later on it appears unable to endure as much shade as the latter tree.

Mountain red cedar is usually a very prolific seeder, especially when growing in the open. Some seed is borne practically every year, but particularly heavy crops are produced at intervals of from 2 to 5 years. Reproduction, however, is generally sparse, which may be due primarily to the tardy germination of the seed. The moist soil in pockets, rocky crevices, and on the borders of constantly watered canyons furnish the best seed-beds and are the sites on which seedlings are most often found. Large quantities of the berries are eaten by birds, which assist in distributing the seed.

LONGEVITY.

Little is known regarding the extreme age attained by mountain red cedar. It appears to grow very slowly and to be rather long-lived. Trees from 6 to 8 inches in diameter are from 130 to 175 years old. Under favorable conditions of growth, this cedar probably reaches an age of at least 250 years, possibly 300 years.

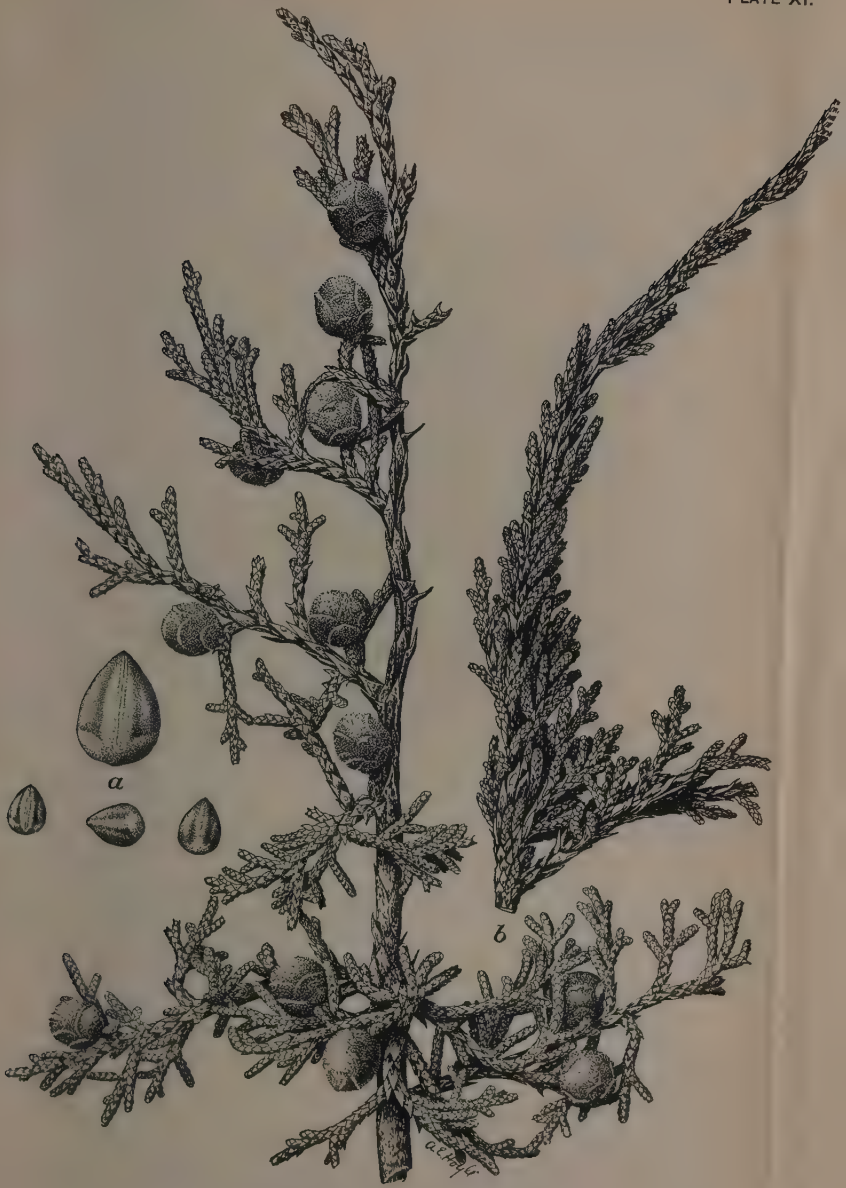
ONE-SEED JUNIPER.

Juniperus monosperma (Engelm.) Sargent.

COMMON NAME AND EARLY HISTORY.

This species is commonly called merely "cedar" or "juniper," lay people as a rule not distinguishing it from Utah juniper, with which it often grows. The name one-seed juniper, derived from the technical name of the tree, is appropriate because the small berries usually contain but one seed. This one-seed character, however, can not be depended upon to distinguish Juniperus monosperma from Utah juniper and Juniperus megalocarpa, since both of these have one-seeded fruit.

There is no record of when this tree was first found by early explorers of the southern Rocky Mountain region. The first botanical account of it was published in 1877, when it was named "Juniperus occidentalis var. β monosperma Engelmann," under which varietal name it was known to botanists until 1896. Investigation then showed it to be distinct from J. occidentalis in its smaller twigs, one-seeded fruit, and in its more southern range.

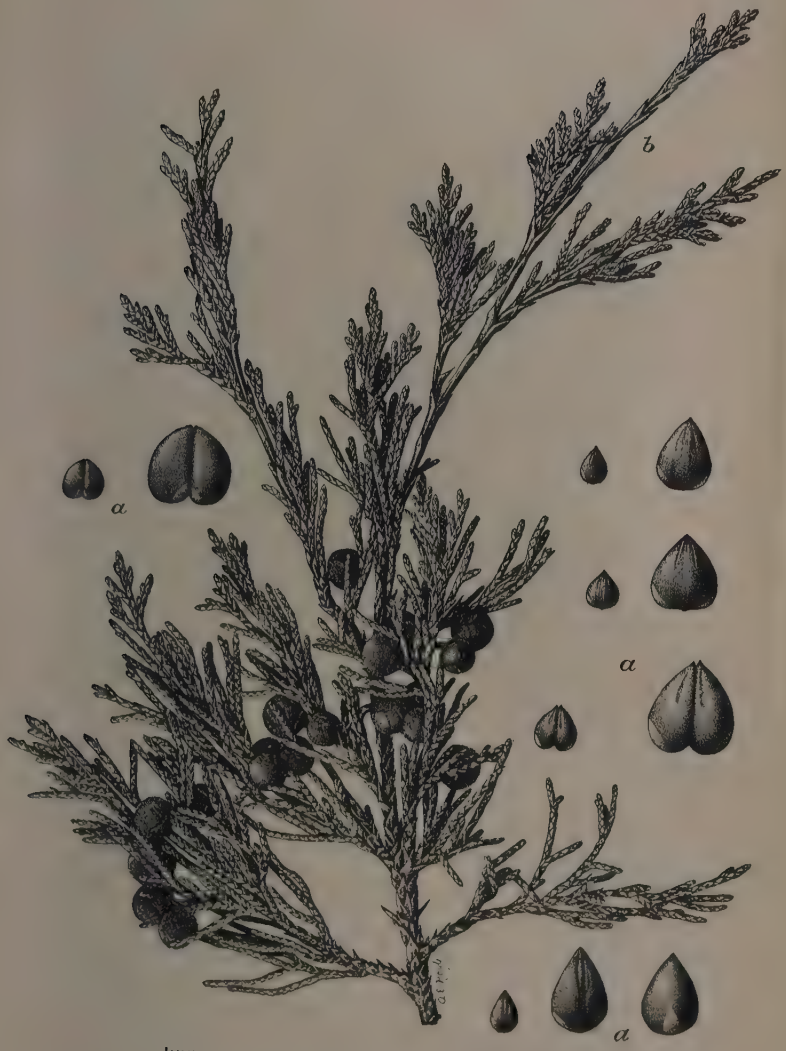


JUNIPERUS MONOSPERMA: FOLIAGE AND RIPE FRUIT.

a, Seeds (enlarged); *b*, young terminal shoot.

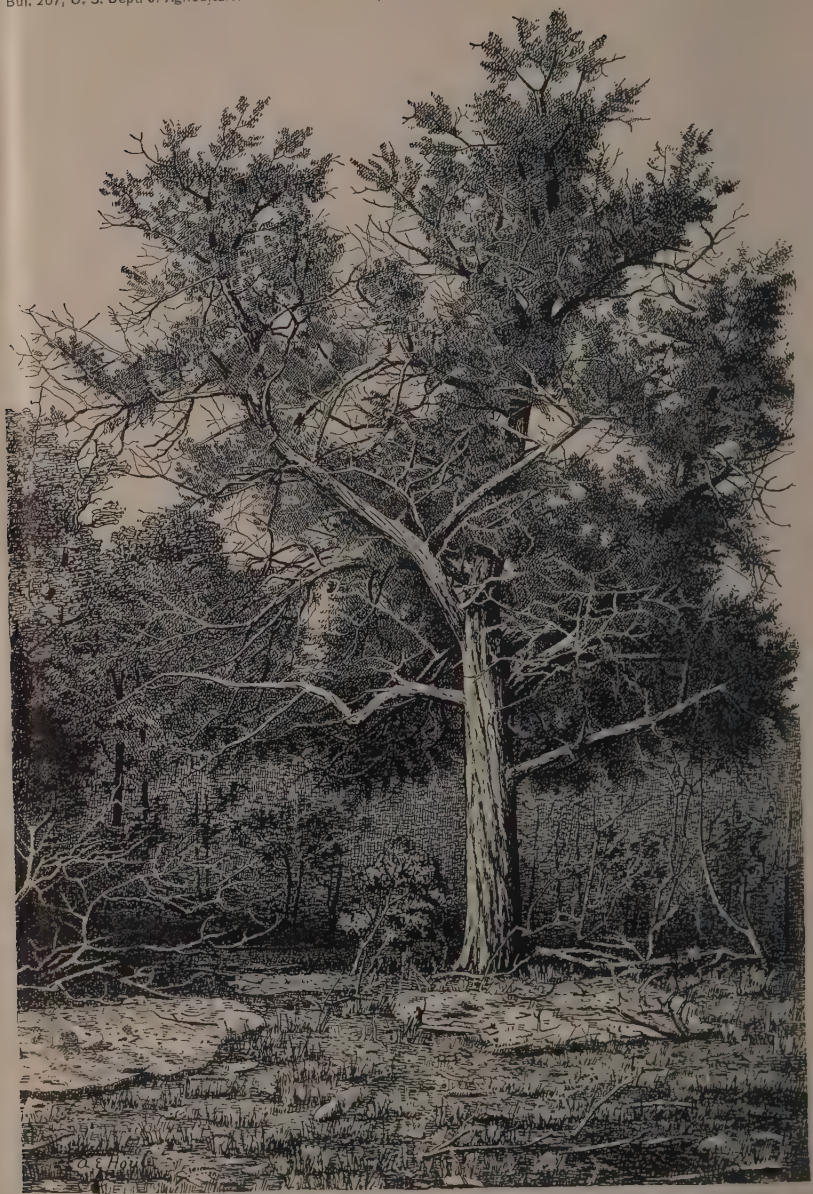
JUNIPERUS MONOSPERMA: BRANCH SHOWING (a) MALE FLOWER BUDS (IN AUTUMN)

PLATE XIII.



JUNIPERUS SABINOIDES: FOLIAGE AND RIPE FRUIT.

a, Variable forms and number of seeds in different berries; *b*, young shoot with large form of leaves.



JUNIPERUS SABINOIDES: TYPICAL TRUNK AND CROWN FORM OF TREE GROWN IN OPEN STAND.

DISTINGUISHING CHARACTERISTICS.

One-seed juniper commonly produces several small trunks from a single rootstock, these stems varying in height from 6 to 20 feet and in diameter from 3 to 6 or more inches. The general appearance is often that of a low-crowned, overgrown bush. Single-stem trees are rare, occurring chiefly in protected places. Their height varies from 30 to 50 feet, or occasionally more, with a diameter of from 12 to 24 inches. In all cases the trunk is rather short, often deeply fluted, and widely buttressed. The crowns are open and irregular, owing to the presence of one or several very large branches near the ground. This is a marked characteristic of the species. In the case of trees growing in sheltered situations the large branches leave the trunk above the ground, while in the desert type of tree such branches are given off either at the very base of the stem or at a point below the surface of the ground. Where one-seed juniper and Utah juniper grow together, the latter species may be recognized by its commonly single trunk, which contrasts sharply with the apparently several-stemmed trunk of one-seed juniper.

The bark of the trunk and large branches is light ashy gray on the outside, and a pale reddish or cinnamon brown beneath. On large trees the bark varies in thickness from one-half to three-fourths of an inch, but on smaller trees it rarely exceeds one-fourth of an inch. It is distinctly soft, fibrous, and stringy, narrowly and deeply divided on older trees by slitlike furrows, the narrow, flat ridges being connected with thin, lateral ones. On smaller trees and large limbs the bark is irregularly divided.

The foliage is a pale grayish green and roughish to the touch, due to the slightly spreading points of the scalelike leaves (Pls. XI, XII). The twigs have a notably squarish form, due principally to the projecting points of the leaves, which as a rule are arranged in pairs, though very occasionally in threes. The ordinary leaves of adult twigs (Pl. XI) are about one-eighth of an inch long, sharp-pointed, slightly spreading, and sometimes marked on their keeled backs with a minute, resinlike gland, which may be lacking in other cases. Leaves of thrifty leading shoots (Pl. XI, *b*) and of seedling trees are from one-third to five-eighths of an inch long, with very keen, spreading points, and a resinous gland on the back.[1] The margins of the leaves are minutely toothed.

Male and female flowers are borne on different trees. The thin-fleshed, sweetish berries (Pl. XI), from about one-eighth to one-fourth of an inch in length, are usually copper-colored, though sometimes bluish, and covered with whitish bloom. They are mostly one-seeded,

[1] Resinous glands occur quite regularly on the backs of leaves borne by vigorous leading shoots, while in the case of the smaller or adult foliage of older trees the glands may be present on some leaves and lacking on others.

in exceptional cases being two or three seeded. The fruit of some trees is peculiar in having the top end of the seed partly exposed. The seeds (Pl. XI, *a*) are pale chocolate-brown and marked at the base with a two-lobed, whitish scar (hilum). The seed-leaves are two in number.

The wood of one-seed juniper is very narrow-ringed, hard, and heavy, with a slight cedarlike odor. The sapwood is nearly white and from three-fourths to about 2 inches thick, usually much thinner in old trees than in young ones. The heartwood varies in color from dull yellowish-brown to pale reddish-brown. When thoroughly seasoned it is very durable, and is one of the best and most frequently used woods for fence posts and fuel in arid parts of the Southwest. The fact that the tree is small, crooked, and knotty confines use of the wood to such local but important purposes. Heartwood of old trees grown in protected situations is fairly soft and straight-grained, and blocks would be suitable for certain grades of lead pencils.

OCCURRENCE AND HABITS.

One-seed juniper grows in the dry, rocky, or gravelly soils of high desert plains and mountain slopes, at elevations between 3,500 and 7,000 feet, though it occurs most extensively between 5,000 and 6,500 feet. It forms an open woodland type of forest, and sometimes pure stands of limited extent, but it is more often mixed with Utah juniper, alligator juniper, piñon, and single-leaf pines, and occasionally with western yellow pine and Pinchot juniper (Texas).

Little is known of this juniper's requirement of light. It can probably endure considerable shade in the seedling stages of growth, but the fact that the older trees invariably have open crowns indicates that it requires full sunlight for its later development.

One-seed juniper is a prolific but irregular seeder, and young plants are found only where through washing or in some other way the seed has become buried in mineral soil. Scanty reproduction is due without doubt to the usually dry and generally unfavorable condition of the soil on which the seed falls. A large part of the seed probably never finds sufficient covering or enough moisture to induce germination.

The tree's persistent growth on high desert plains and mountain slopes makes it important in the maintenance of protective woodland cover in the Southwest.

LONGEVITY.

In the more favorable situations the growth of this species is generally uniform and fairly rapid for a juniper. In arid soils and on exposed sites, however, the growth is irregular and often extremely slow. The exact age that one-seed juniper may attain has not yet

been determined, but it is probably very long-lived. The oldest trees doubtless reach an age of at least 400 or 500 years. Trees from 5 to 7 inches in diameter are from 170 to 195 years old, and those from 10 to 12 inches are from 315 to 375 years old.

MOUNTAIN CEDAR.

Juniperus sabinoides (H., B. and K.) Nees.

COMMON NAME AND EARLY HISTORY.

Strictly speaking, mountain cedar is not a Rocky Mountain species, since it occurs mainly in central and southeastern Texas and adjacent parts of Mexico. It is included here, however, because its geographic range has climatic and topographic features similar to those in parts of Arizona and New Mexico, and also in order to include all of the junipers occurring west of the one-hundredth meridian, which roughly divides the forest regions of the West from those of the East. The tree has no generally recognized common name, being known in some parts of its range as "mountain cedar" or "rock cedar," and in others as "mountain juniper," or even "juniper cedar." The name "mountain cedar" is the one most commonly applied by those who use the wood of the tree. It is appropriate also because it indicates the general nature of the tree's habitat in Mexico, though in the United States it grows mainly on limestone hills.

Mountain cedar was discovered first in Mexico and subsequently in Texas, but the exact dates of these discoveries are unknown. The earliest technical names applied to the tree is "Cupressus sabinoides H., B. & K.," published in 1817. Subsequently other botanical names given to it were published, from 1826 to 1877. It was not until 1847 that its present name, Juniperus sabinoides (H., B. & K.) Nees (based on Cupressus sabinoides), was permanently established, and for the reason that the name "Cupressus sabinoides H., B. & K." was not generally recognized as applying to our mountain cedar.

DISTINGUISHING CHARACTERISTICS.

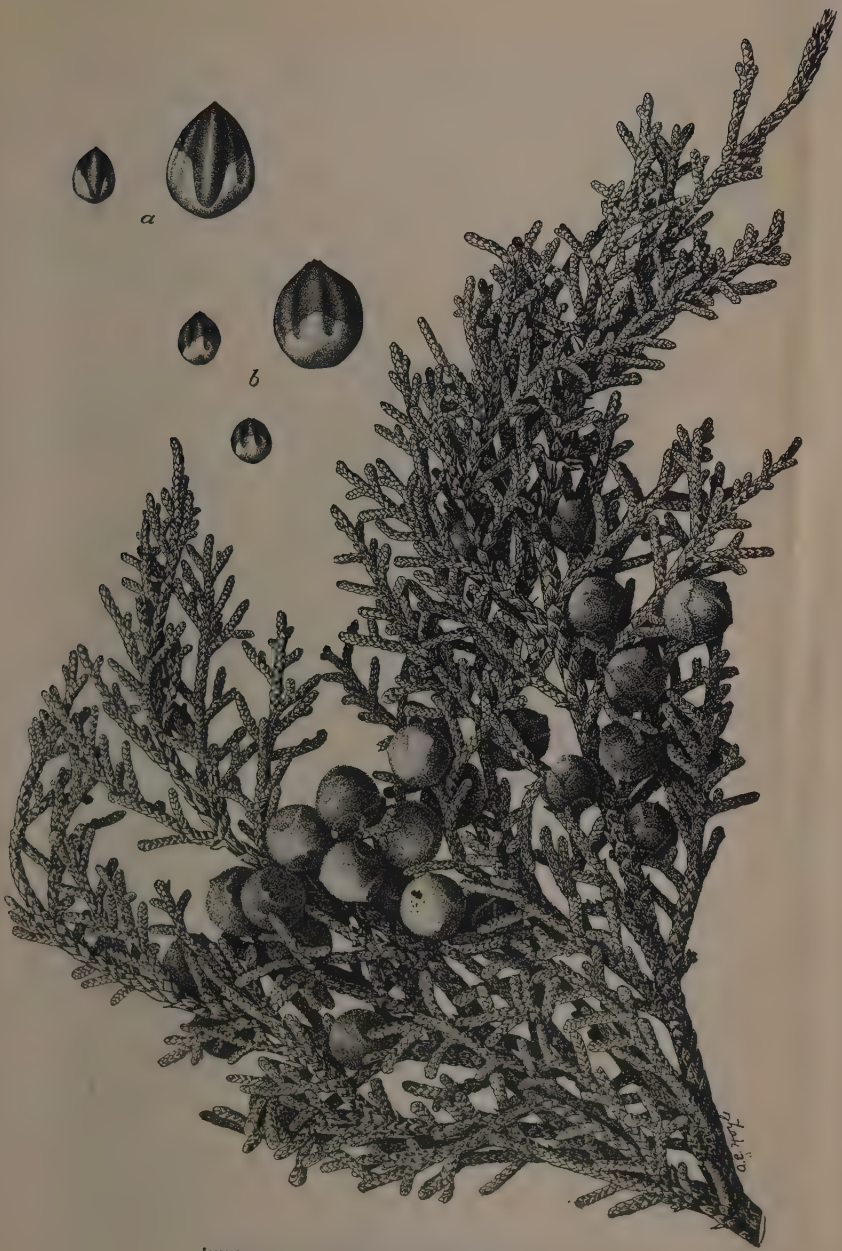
The crown of old mountain cedar trees is broadly rounded, while in young ones it is widely conical. Old trees develop very open crowns, while those of younger trees are more compact. The tree is seldom more than 18 feet high, though in sheltered or otherwise favorable situations it may attain a height of 35 or more feet and a diameter of from 12 to 18 inches. Seldom more than one-third of the trunk is free of branches (Pl. XIV), and in very dry, exposed places the tree is often only a many-stemmed, widely spreading shrub, the crooked stems occasionally sprawling upon the ground. In general, the trunks of this juniper are rarely straight and cylin-

drical for any considerable length, most of them being crooked or variously bent and with irregular ridges and hollows. It is rare for old trees to have single stems. As a rule, the trunks are divided near the ground into large, crooked, sharply ascending branches. The bark is characteristically thin, about one-fourth of an inch thick on small or medium-size trees and from one-third to one-half of an inch on large, old ones. It weathers to a brownish-gray, beneath which the layers of bark are a deep chestnut-brown. It is very stringy and fibrous, and irregularly broken into laterally connected, narrow ridges and deep furrows. Long-persisting loosened shreds of bark often give old trees a more or less shaggy appearance. Bark of the branches is dark brown mottled with white.

The deep bluish-green foliage of mountain cedar is rather roughish and prickly to the touch. The slender twigs are noticeably four-sided, due to the four-ranked arrangement of the scalelike, sharp-pointed, closely overlapping leaves, which occur in pairs and are about one-sixteenth of an inch long (Pl. XIII). The laterally compressed upper ends of the leaves give a keeled appearance to their backs, and emphasize this four-sided feature. The edges of the leaves bear minute, irregular teeth. Vigorous terminal shoots and young plants have very keenly pointed leaves, from one-fourth to one-half of an inch long, the points of which are often slightly spreading. The backs of the leaves are marked with a minuted pit or bear a resinous gland (Pl. XIII).

Male and female flowers are borne on separate trees. The ripe berries (Pl. XIII), matured in September at the end of one season's growth, are deep blue and with a whitish bloom. They have a tough skin and a thin, pungent, sweetish pulp. As a rule, only the points of the female flower scales are visible on the surface of the berries. The berries contain from 1 to 2 light brown, shiny seeds (Pl. XIII, *a*), which are pointed, slightly grooved at the top end, and marked at the bottom with a low, narrow, scalelike scar (hilum). The seed-leaves are two in number, and narrowly lance-shaped. Seedlings continue to bear the long awl-shaped form of leaves for 3 or 4 years, when these are gradually succeeded by the shorter, adult form.

The wood of mountain cedar is moderately heavy (about 43 pounds per cubic foot, seasoned), rather hard, exceedingly narrow-ringed, and of a clear cinnamon-brown color, interspersed with irregular paler streaks. The sapwood is very thin, seldom more than one-half of an inch thick. Freshly cut, dry, or green wood has a strong cedarlike odor. The heartwood is very durable, and the best sticks are useful for fence posts, telephone and telegraph poles, and light-traffic ties. It is much used locally for fuel. The wood of old trees is brittle and can be cut with an easily parted chip, qualities that make clear sections suitable for pencil wood.



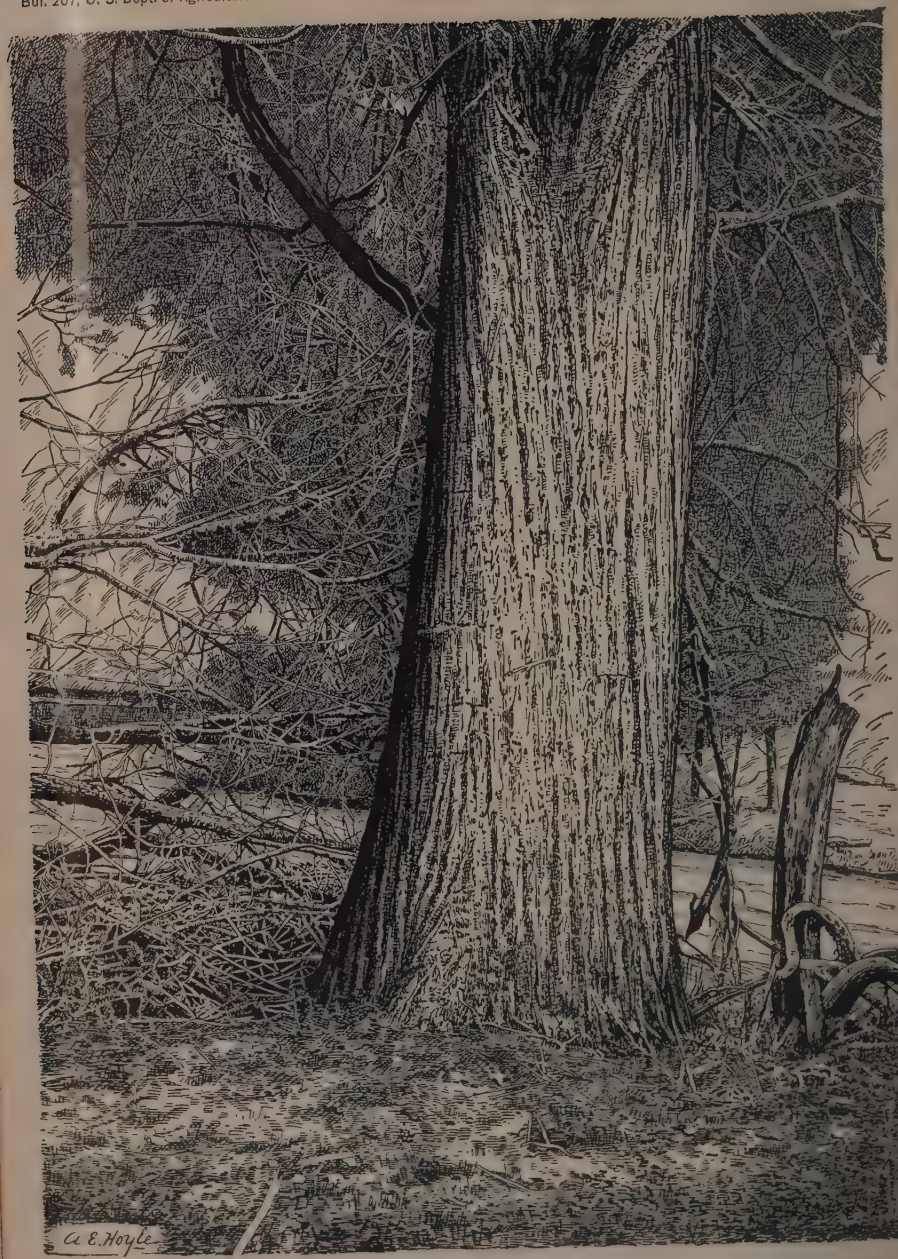
JUNIPERUS UTAHENSIS: FOLIAGE AND RIPE FRUIT.

a, Narrow side of seeds; *b*, broad side of seeds (natural size and enlarged twice natural size).

JUNIPERUS UTAHENSIS: BRANCH FROM YOUNG TREE SHOWING LARGER OR JUVENILE FORM OF LEAVES.

JUNIPERUS MEGALOCARPA: FOLIAGE AND RIPE FRUIT.

a, Showing flat side of seeds (natural size); *b*, showing opposite (narrow) side of seed (natural size and enlarged twice natural size).



JUNIPERUS MEGALOCARPA: SHOWING TYPICAL BARK OF LARGE TREE (26 INCHES IN DIAMETER AND 50 FEET HIGH).

OCCURRENCE AND HABITS.

In the United States mountain cedar forms very dense, pure, or nearly pure, stands, sometimes of vast extent, as on the semiarid limestone hills of the Edwards Plateau in central Texas. It usually grows in dry rocky, gravelly, or sandy soils, often in crevices of bare rock. Mountain cedar also grows both in pure stands and in mixture with other species in lower, sheltered situations in deep-washed soil of good quality. Interspersed with mixed stands are often groups and scattered trees of one-seed juniper, Pinchot juniper, Mexican walnut, live oak, Spanish oak, Durand oak, cedar elm, and hackberry. The dense, sometimes almost impenetrable, stands of this juniper on limestone are locally known as "cedar breaks."[1]

In this country mountain cedar occurs chiefly at elevations between 600 and 2,000 feet. Little is known of its range and habitat in Mexico, where it is said to occur much more extensively and at higher elevations than in the United States.

Mountain cedar is very tolerant of dense shade during the seedling and early sapling stages, as shown by the existence of extremely dense thrifty stands. It appears to be much less tolerant later in life, when its crown becomes thinner and more open (Pl. XIV). In ability to endure shade, however, it compares favorably with red cedar (*Juniperus virginiana*), but probably it would not maintain itself under long suppression as does the latter tree. Local reports of mountain cedar having come up on an area immediately after a full stand of oak had been cut off give further evidence of its tolerance during early life, since on such areas it must have existed for a number of years in a suppressed condition, and recovered when the oak was removed.

Mountain cedar bears seed abundantly, and reproduction is plentiful in loose, permeable soils, and in broken, rocky formations, and also in soil-filled pockets and crevices of bare rock. The sweetish berries are eaten by birds, which assist greatly in a wide distribution of the seed.

LONGEVITY.

Juniperus sabinoides is moderately long-lived, though the extreme age attained is at present unknown. Trees from 5 to 7 inches in diameter, on exposed, rocky sites, are from 150 to 180 years old, while trees from 8 to 10 inches in diameter, in sheltered places on deep, permeable, sandy or gravelly soil, where growth is most rapid, may be only from 95 to 125 years old. Large trees occasionally found in the driest situations are probably at least 250 years old.

[1] Popularly the allusion probably is to the fancied similar lowland "canebrakes," but properly this name appears to refer to the physiographic nature of the plateau region in which dense growths of mountain cedar occur.

UTAH JUNIPER.[1]

Juniperus utahensis (Engelm.) Lemmon.

COMMON NAME AND EARLY HISTORY.

Like most of the other brown-wooded junipers, Juniperus utahensis has no distinctive common name. In the region where it grows, the people usually call it merely "juniper" or sometimes "cedar," seldom if ever distinguishing it from the other species of its kind. The discovery of this tree in Utah led to its being given the technical name "Utahensis," from which the common name employed here is derived. While Utah juniper is the most distinctive name that can be suggested, it is not entirely appropriate, because the tree is not confined to Utah, a large part of its range, in fact, lying outside that State.

Utah juniper was discovered sometime between 1867 and 1869, during the exploration of Nevada and Utah by the United States Geological Survey. The botanical history of the tree shows that its distinguishing characters were imperfectly known until comparatively recent times. The earliest account of it was published in 1871 under "Juniperus occidentalis Watson," the writer supposing it to be a form of the western juniper. In 1877 it was described as "J. californica var. utahensis Engelm.," and finally, in 1890, as "J. utahensis Lemmon." The tree is distinct from the California and western junipers both in its botanical characters and geographic range.

DISTINGUISHING CHARACTERISTICS.

Utah juniper is commonly a low, very short trunked, or many-stemmed, bushy tree, from 6 to 12 feet high,[2] and from 4 to 8 or more

[1] In 1897 Prof. Aven Nelson found a "shrublike tree" juniper in Wyoming (Red Desert region from Seminole Mountains to Green River) which in 1898 he named Juniperus knightii (Bot. Gaz. xxv, 198, fig. 1, 2, 1898).

The writer has not seen authentic specimens of this juniper, and was, therefore, unable personally to decide what final disposition should be made of the tree in the present work. Several authors have, however, reduced Juniperus knightii to a synonym of J. utahensis. Judging from Prof. Nelson's description and illustrations of J. knightii it would seem to be very closely related to J. utahensis and J. megalocarpa. It resembles the former species particularly in the low-branched several-stemmed habit of its crown, and both of these junipers in its large fruit and single large seed. The "copper-colored" fruit ascribed to J. knightii is not, however, strictly speaking, characteristic of J. utahensis and J. megalocarpa.

The author's technical description (loc. cit.) of J. knightii, slightly condensed, follows:

"A scraggy shrub or small tree, usually much branched from the base—i. e., trunkless or breaking up into several subequal trunks also freely branched, branches widely spreading, the lowest close to the ground and almost resting upon it, round-topped, 3-7 meters high or possibly in places exceeding this; leaves 3-ranked, closely appressed * * * entire or rarely minutely denticulate, neither pitted nor glandular * * * berrylike cones blue-green or copper-colored * * * broadly oval, 7-10 millimeters long, dry, the coalesced scales thin, in dried specimens closely and tenaciously adherent to the large single seed; the seed ovate, obtuse, slightly grooved above, rounded or swollen at the base; fruit possibly not maturing till the second year."

[2] The several-stemmed forms of Utah juniper are similar in general appearance to like forms of the one-seed juniper. In the majority of cases, however, if not in all, the trunklike branches of Utah juniper leave the trunk near or above the ground, while in the case of one-seed juniper, the two or more stems usually arise from the main root-stock, or collar, at or slightly below the surface of the ground.

inches thick near the ground, with a wide, rounded, rather open crown of numerous upright, twisted limbs. The short trunk is apt to be one-sided with conspicuous hollows and ridges. Its thin, whitish bark, from one-fourth to three-eighths of an inch thick on large trunks, is cut into long scales.

The minute, sharp-pointed, scalelike, pale yellowish-green leaves (Pl. XV), generally without a pit on the back, are arranged mostly in alternately opposite pairs, and closely overlap each other in four rows on the slender, stiff-looking twigs. Sometimes there are six rows, in which case three leaves occur together at a point. Leaves of vigorous leading shoots are much larger and keenly pointed (Pl. XVI), while those of seed lings are needlelike. The margins of the leaves are minutely toothed. The twigs have a roundish appearance. Leaves of each season's growth persist from 10 to 12 years, or even longer. The bark of larger twigs which have recently shed their leaves is pale reddish-brown and scaly.

Male and female flowers are usually borne on different twigs of the same tree, though sometimes the male flowers are borne on one tree and the female on another. Ripe berries (Pl. XV), matured in the autumn of the second year, have a smooth, tough, red-brown skin, covered with a whitish bloom, which gives the berries a bluish tint. The pulp of the berries is thin, dry, and sweet. They usually contain but one seed (occasionally two), pointed at the top, rather sharply angled (Pl. XV, *a*, *b*), and marked nearly to the top by what appears to be a scalelike, basal covering (hilum). The surface of the berries shows projecting points, which are the ends of minute female flower scales. The pointed seed-leaves are usually 5 in number, but vary from 4 to 6.

The hard, heavy wood of Utah juniper is generally very narrow-ringed, the rings in stunted trees being extremely narrow. The sapwood is very thick and white, while the heartwood, of a light yellowish-brown color, is less pungent in odor than that of other junipers. When thoroughly seasoned the wood is exceedingly durable. Utah juniper is too small and imperfect in form for commercial purposes, though where it is abundant the wood is much used for fuel and fence posts.

OCCURRENCE AND HABITS.

Utah juniper grows on desert foothills and mountain slopes in dry rocky, gravelly, or sandy soils, at elevations between 5,000 and 7,000 feet. It forms extensive, rather open, pure stands, and also grows mixed with single-leaf pine, one-seed juniper, and desert shrubs. Like its associate, one-seed juniper, the tree is important to the forester through its ability to form a woodland type of cover in arid regions.

Little is known regarding the tree's light requirements or its reproduction. In the intolerance of shade, it appears to be very similar to the western and one-seed junipers. It produces an abundance of berries at intervals of about two years, a few being borne nearly every year. Reproduction is usually sparse and widely scattered, due to the failure of most of the seed to germinate in the exceedingly dry soils of the region where the tree grows.

LONGEVITY.

Utah juniper is rather long-lived, the maximum age being about 300 years. Trees from 6 to 10 inches in diameter are from 145 to 250 years old.

BIG-BERRIED JUNIPER.

Juniperus megalocarpa Sudworth.

COMMON NAME AND EARLY HISTORY

This recently discovered juniper is not distinguished by settlers in its range from other southwestern junipers and "cedars." The common name "big-berried juniper," adopted here, is derived from the technical name in reference to the large size of its fruit, a striking and distinctive characteristic.

It was discovered by Mr. W. R. Mattoon of the Forest Service on September 22, 1906, in the southwest corner of the Datil National Forest, Socorro County, southwestern New Mexico, where only about 25 trees were found.[1]

The tree was named and described in June, 1907, from specimens, field notes, and a photograph obtained by Mr. Mattoon.[2]

DISTINGUISHING CHARACTERISTICS.

Big-berried juniper is one of the largest and best formed of our southwestern junipers. It varies in height from 30 to 50 feet, and in diameter from 2 to 4 feet. The crown is compact, broadly pyramidal, with short, stout branches. The trunks are clear of branches for from 15 to 20 feet, or more, and have dark reddish-brown, finely fissured bark, shredded on the surface (Pl. XVIII). The branchlets (Pl. XVII) are short, very dense, and clothed with pale yellowish-green, sometimes bronze-green, foliage, On young trees the foliage

[1] This station, approximately in section 11 or 14, township 9 south, an unsurveyed region, is on the west bank of the San Francisco River at a point about halfway between the towns of Alma and Frisco, and 3 miles above the "Widow Kelley's Ranch."

Forest Supervisor William H. Goddard later reported having seen a juniper, which may prove to be J. megalocarpa, on a small tributary of San Francisco River at a point about 6 miles west of Pleasanton, N. Mex., some 20 miles from Mr. Mattoon's type locality and near the east border of Arizona. The writer has not seen specimens of this tree.

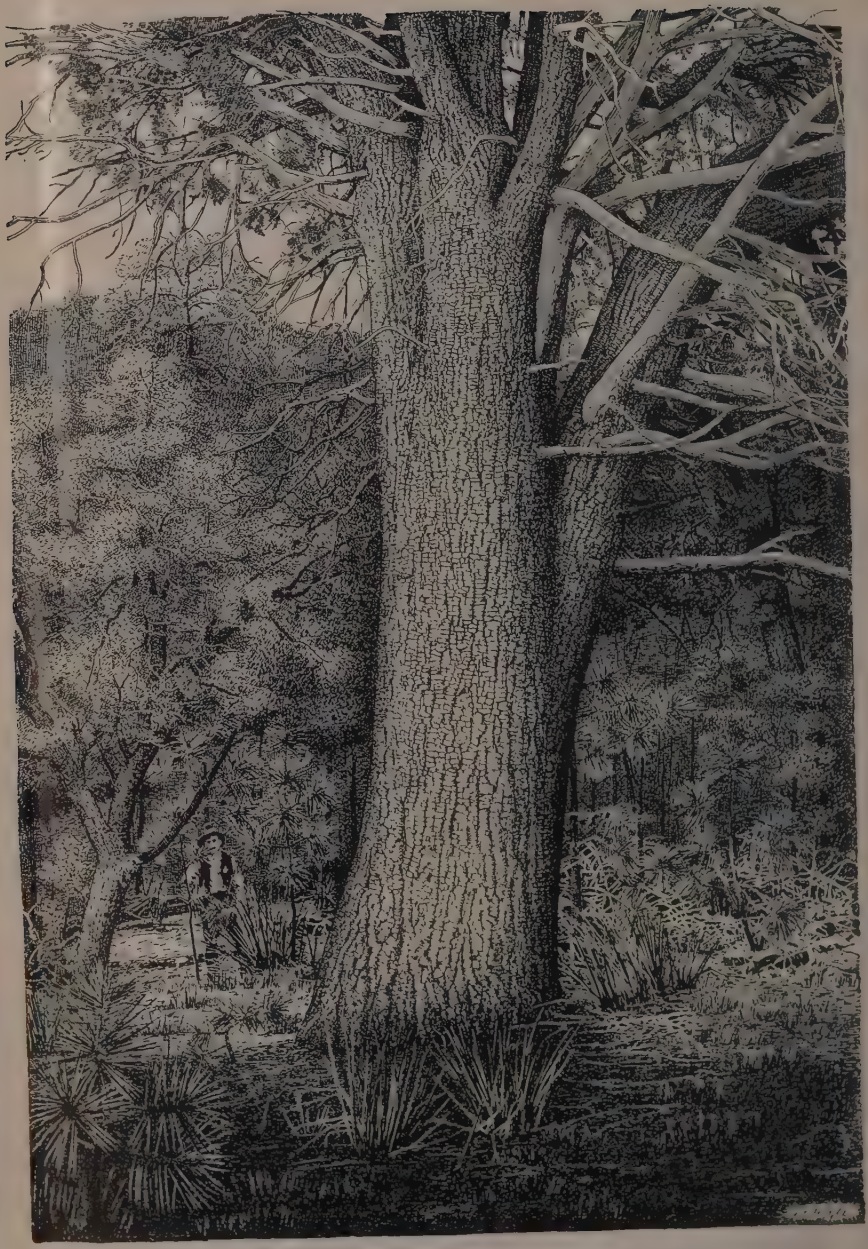
Prof. C. S. Sargent also informed the writer (Nov. 6, 1914) that several years ago he collected specimens of this tree on the rim of Oak Creek Canyon, 20 miles south of Flagstaff, Ariz., and that three or four years later Prof. Percival Lowell also collected specimens at Angell, near Flagstaff, Ariz.

Further explorations should extend the tree's range.

[2] Forestry and Irrigation, XIII, figs. 1 and 2 (1907).

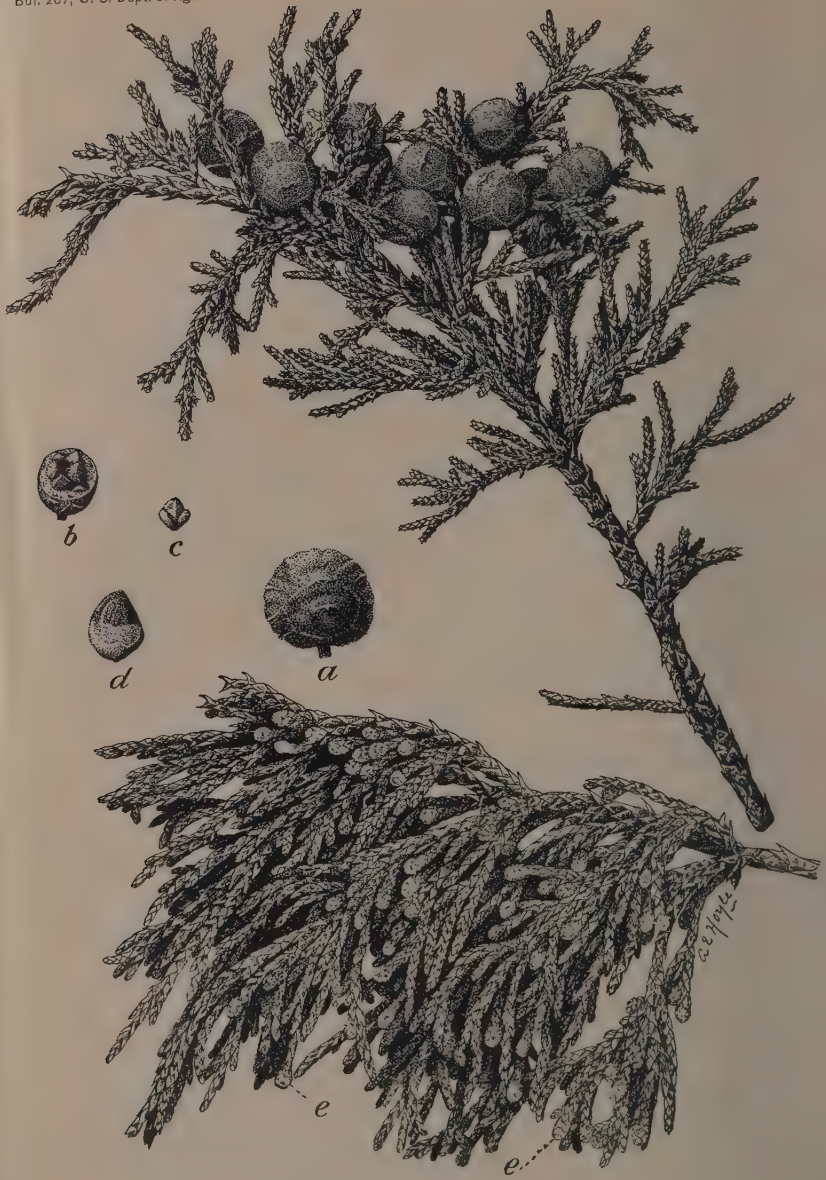
JUNIPERUS PACHYPHLOEA: FOLIAGE AND RIPE FRUIT.

a, Seeds showing variation in form and number in different berries (natural size and enlarged twice natural size); *b*, seedling 10 days old; *c*, seedling one year old.



JUNIPERUS PACHYPHLOEA: SHOWING TYPICAL BARK OF LARGE TREE (37 INCHES IN DIAMETER).

JUNIPERUS PACHYPHLOEA: SHOWING TYPICAL STUNTED FORM OF TREE GROWN IN EXPOSED SITUATIONS.



JUNIPERUS FLACCIDA: FOLIAGE AND RIPE FRUIT.

a, Detached large fruit; *b*, berry with top removed showing tiered irregular arrangement of seeds (enlarged one and one-half times natural size); *c*, *d*, detached seeds (natural size and enlarged four times natural size); *e*, male flowers in autumn (natural size).

often has a whitish tinge. The sharp-pointed, scalelike leaves occur in twos and threes, closely overlapping each other, and usually marked on the back with a pit, which often contains a rather conspicuous resin spot. The leaves of vigorous leading shoots have slightly spreading, somewhat slender points and long (decurrent) bases. The margins of the leaves are provided with irregular, minute teeth.

Male and female flowers are borne on separate trees. The fruit of Juniperus megalocarpa matures at the end of the second season. It is spherical or slightly elongated in shape and of exceptionally large size, varying from about nine-sixteenths to eleven-sixteenths of an inch in diameter or length (Pl. XVII). The surface of the berries is roughened only by the united female flower scales and their rather tough skin is reddish-brown and coated with whitish bloom. The sweet flesh of the berries is thick, dry, and firm, and in old and fully matured berries scarcely resinous, though from the presence of old resin cells in the pulp it is evident that immature or newly ripened fruit has a distinct resinous flavor. The berries usually contain but one glossy, chestnut-brown seed—rarely two—marked at the base by a conspicuous 2-lobed scar (hilum), which has distinct short pits or shallow grooves. The top end of the seed is usually abruptly flattened on its two broad sides so as to form a chisellike edge (Pl. XVII *a*, *b*, view of opposite sides). The seeds readily fall out of the dry pulp when the latter is cut or broken open. The number of seed-leaves is unknown.

Juniperus megalocarpa resembles J. utahensis in its large one-seeded fruit and also in the general appearance of its foliage. The much longer vertical creases and furrows and the pointed top of the seeds of J. utahensis distinguish this species from J. megalocarpa.

The wood of big-berried juniper has not been collected, but it is known to have a rather strong, cedarlike odor and to be yellowish-brown in color. Scarcity of post material and fuel in the region where this juniper grows should make it valuable for these purposes.

OCCURRENCE AND HABITS.

The trees found on the Datil National Forest were scattered singly and in small, open groups on deep washed, rather rich, sandy loam or gravelly soils of benches and terraces, from 50 to 150 feet above the bed of the San Francisco River, where the elevation is about 5,400 feet. Interspersed with them were piñon, one-seed juniper, and Emory oak, while mountain red cedar, Arizona oak, and blue oak occur in the same general region.

Big-berried juniper appears to be similar in its requirements of light and reproductive capacity to Utah juniper. No seedlings were found in the vicinity of the fruiting trees, which produce an abun-

dance of berries. The absence of young trees may have been due, however, to the overgrazed state of the ground, which doubtless prevented germination of the seed.

This species is suitable for planting on dry foothills and lower mountain slopes of the Southwest, where it should succeed at elevations between 2,500 and 6,000 feet.

LONGEVITY.

Complete information is not available regarding the longevity of big-berried juniper. Judging from the size of the trees produced in the comparatively dry habitat, however, it probably attains an age of not less than 250 or 300 years.

ALLIGATOR JUNIPER.

Juniperus pachyphlœa Torrey.

COMMON NAME AND EARLY HISTORY.

Alligator juniper is unique in the thick, sharply checkered bark of its trunk (Pl. XX), the resemblance of which to the body scales of an alligator suggested its widely accepted common name, a characteristic which also distinguishes it sharply from all other native junipers. It is sometimes known as "oak-barked juniper" and "thick-barked juniper."

Alligator juniper was discovered in 1851 on the Zuni Mountains of northwestern New Mexico by Dr. S. W. Woodhouse, then a member of Capt. Sitgreaves's exploring party, which descended the Zuni and Colorado Rivers. An account of this discovery was published in 1853,[1] and the tree was technically named and described in 1858.

Three garden varieties of alligator juniper, recently established by Barbier,[2] are distinguished in cultivation, namely, Juniperus pachyphlœa conspicua, J. pachyphlœa elegentissima, and J. pachyphlœa ericoides.

DISTINGUISHING CHARACTERISTICS.

This species is one of the most massive of our junipers. In early life the crown is open and broadly conical, and in old age, dense and round. The trunk is short and clear of branches for 6 or perhaps 10 feet. As a rule, the tree attains a height of from 30 to 40 feet, and a diameter of from 1½ to 3½ feet. Exceptional trees are from 50 to 65 feet or more in height, and from 4 to 6 feet in diameter, with from 15 to 20 feet of clear trunk. In exposed dry situations it is stunted, the trunks often dividing at the ground into several twisted stems (Pl. XXI). The deeply furrowed bark, from one-half

[1] Report of an expedition down the Zuni and Colorado Rivers under the command of Capt. L. Sitgreaves, 35, 1853.

[2] Mitteil. Deutschen Dendr. Gesellschaft 1910, 139, 289.

of an inch thick on trunks 6 to 8 inches through to about 3½ inches on the larger ones, has its flat ridges sharply cut into rectangular plates (Pl. XX). Externally it is usually weathered to a bright ashy-gray, beneath which the color is a dull, dark chocolate-brown. When the slender twigs shed their leaves, they have smooth, reddish purple-brown bark, which becomes scaly as the branchlets grow larger.

The foliage is a pale blue-green; the alternately opposite pairs of minute, scalelike leaves (Pl. XIX), closely pressed and overlapping each other, are arranged in four ranks, giving the twigs a four-sided appearance. Each leaf bears a tiny but conspicuous resin-gland on its back. Leaves of young shoots and seedlings (Pl. XIX, *b*, *c*) are narrowly lance-shaped and keenly pointed. The margins of the leaves are minutely toothed.

Male and female flowers are borne on different trees. The berries, which are matured by October of the second year, vary in shape from spherical to slightly elongated, and may be from about three-eighths to nearly one-half of an inch in diameter or length. Their surface is more or less marked by the points of united female flower-scales, and further roughened by irregular little knobs (Pl. XIX). The firm, deep purplish-brown skin of the berries is covered with a whitish bloom. The flesh of mature berries is dryish and resinous, that of immature ones being very resinous. They contain from 1 to 4 brownish, pointed, distinctly grooved seeds (Pl. XIX, *a*), the bases of which bear a short, two-lobed scar (hilum). The seed-leaves are two in number, pointed, and about one-half an inch long. Ripe berries are shed rather slowly, in some cases continuing to fall during the winter and summer following their maturity.

The wood of alligator juniper is rather light, soft, brittle, and very narrow-ringed. The sapwood is comparatively thin and of a pale straw-color; the heartwood is light brown with a faint reddish tinge, irregularly marked with paler streaks. Seasoned heartwood is durable. Alligator juniper is locally much used for fuel and fence posts, a number of which are often split from large clear logs (Pl. XX). The wood "cuts" freely, with an easily parted chip, a quality which would make it useful for lead pencils, and the probable future use of the best grades for this purpose is likely to give the wood considerable commercial value.

OCCURRENCE AND HABITS.

Alligator juniper is of frequent occurrence throughout its range, sometimes in very scattered, open, pure stands, but oftener mixed with Emory oak, Arizona oak, blue oak, piñon, and Mexican piñon. It grows in the driest rocky and gravelly soils on mountain slopes, plateaus, and canyon sides, where it is likely to be much stunted and distorted. The best developed trees are found in moist, deep washed

soils of canyon bottoms and in protected places on the lower mountain benches. The tree's vertical range extends from about 4,500 to nearly 8,400 feet elevation, but it is most abundant between 5,500 and 7,000 feet. Because of its great hardiness this species is one of the most useful of southwestern junipers for maintaining a protective woodland forest on exposed arid hills and lower mountain slopes.

Alligator juniper endures moderate shade during the seedling stage and for a few years afterwards, but requires full overhead light for later development. Continued, dense side shade produces a long clear trunk, and a short, thin-branched, open crown.

This tree bears seed abundantly almost every year, and reproduces itself plentifully whenever the berries find lodgment in washed or broken soil. Reproduction is especially good in light shade where old trees have been cut out. Severely pollarded trees and high-cut stumps often sprout vigorously. Birds eat considerable quantities of the berries and thus assist in disseminating this species, while in seasons when food is scarce squirrels and other rodents eat a good many of the seeds.

LONGEVITY.

Alligator juniper is a very long-lived tree. It grows slowly, however, even in the most favorable situations, and is extremely slow on the least favorable sites. The exact age of very large trees has not been determined. Trees from 12 to 20 inches in diameter are from 165 to 290 years old, while those from 3 to 5 feet in diameter must be from about 500 to 800 years old.

DROOPING JUNIPER.

Juniperus flaccida Schlechtendal.

COMMON NAME AND EARLY HISTORY.

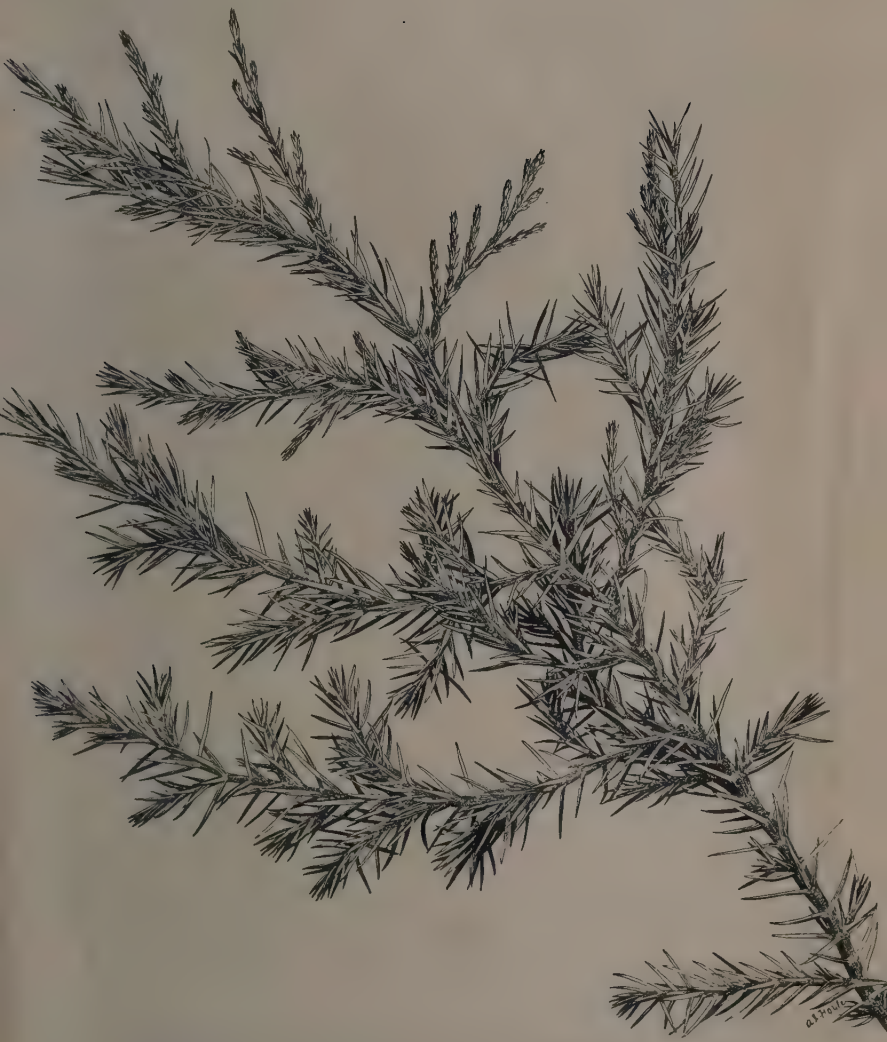
Although very distinct in its general appearance from other southwestern junipers, this species is doubtless unknown to many lay people, and unfamiliar even to a good many foresters and botanists, chiefly because in the United States it grows in an isolated and little frequented section of the country. It is, in fact, essentially a Mexican species, the principal part of its range being in Mexico. The few stockmen and prospectors who have seen the tree know it only as "cedar" or "juniper." The name "drooping juniper," derived from the technical term flaccida, seems both appropriate and distinctive, in that it refers to the nodding or pendent habit of the branchlets, which is a conspicuous and distinctive characteristic of this tree (Pl. XXVI). "Loose-growing Mexican juniper" and "loose-growing juniper" are book names applied about 50 years ago, but neither of these appear to be appropriate, nor has either been adopted in this country.

JUNIPERUS FLACCIDA: SHOWING DROOPING HABIT OF BRANCHLETS OF TREES IN EXPOSED SITES.

a, Detached leaf showing resin gland on back (enlarged five times natural size).

JUNIPERUS FLACCIDA: SHOWING PENDENT BRANCHLETS OF TREES IN SHELTERED SITES.

a, Female flowers (in autumn).



JUNIPERUS FLACCIDA: PRIMARY FOLIAGE OF SEEDLING (ABOUT 6 YEARS OLD).

JUNIPERUS FLACCIDA: SMALL TREE SHOWING CHARACTERISTIC OPEN CROWN AND DROOPING HABIT OF BRANCHLETS IN SHELTERED SITE (ABOUT ONE TWENTY-FIFTH NATURAL SIZE).

Drooping juniper was first discovered in Mexico by the German botanist Schiede, who found it in June, 1830,[1] at "Atotonilco el Chico," [2] State of Hidalgo. Ehrenberg is also said to have found the drooping juniper at Regla and at other points in Mexico at elevations between 6,000 and 8,000 feet. It first became known to botanists as a Mexican tree in 1838, when it was technically described and named Juniperus flaccida Schlech. The French botanist Carrière informs us that the tree was brought to Europe in that year for purposes of cultivation. The first discovery of drooping juniper within our border was in 1885, when Dr. Valéry Harvard, United States Army surgeon and botanist, found the tree in the Chisos Mountains [3] of southwestern Texas, which is the only location now known for it in the United States.

DISTINGUISHING CHARACTERISTICS.

Drooping juniper varies in size from a bushy tree 8 to 15 feet in height and 3 to 6 inches through to one of medium size, from 20 to 25 feet tall and 12 to 20 inches in diameter. The best developed specimens have straight trunks, clear of branches for from 10 to 15 feet, and rather open, narrowly pyramidal crowns. Trees growing in dry, exposed places are rarely over 10 feet high, densely branched to the ground, and have a dome-shaped crown. The crown is composed of wide-spreading ascending branches, at the ends of which the slender, drooping twigs (Pls. XXIII, XXIV) give the tree a graceful, weeping appearance. In the case of trees growing in deep shaded canyon bottoms (Pl. XXVI) the drooping habit is especially pronounced, the pendent branchlets often being a foot or more in length. Trees on exposed, drier slopes have very much shorter twigs (Pl. XXII).

The trunk bark is externally grayish brown in color, while within it is a purple or russet brown. On large trunks the bark is fibrous but firm, and distinctly marked with deep furrows and narrow anastomosely arranged ridges. It varies in thickness from one-half an inch on small trees to 1½ inches on larger trees. The bark of twigs that have recently shed their leaves is a russet-brown or purple-brown, composed of easily detached, very thin scales. Bark of the branches is also scaly, but grayish-brown.

The pale yellowish-green foliage is somewhat prickly to the touch, owing to the slightly spreading, keenly pointed leaves. The ordinary adult scalelike leaves are about one-eighth of an inch long (Pl.

[1] Schlechtendal in Linnæa, Zwölfter Band, 495. 1838.

[2] "Atotonilco el Chico," also once called "El Chico," a small mining town in Mexico, is now known as Atotonilco and lies due north and near Patchuca, the capital of Hidalgo.

[3] Dr. Harvard's note upon this species (Proceedings of the U. S. Nat. Mus., viii, 504, 1885) is exceedingly brief: "Small tree, only seen in the Chisos Mountains."

XXIII, *a*), while leaves of terminal or rapidly grown shoots are from one-fourth to nearly one-half an inch long. The margins of all leaves have very minute teeth. Adult leaves are arranged alternately in pairs in four ranks, with a prominent resinous gland on the back of each (Pl. XXIII, *a*). The bristlelike, spreading leaves of seedlings, however, are usually arranged in threes (Pl. XXV), but sometimes in twos, these types of leaves persisting for several years.

Male flowers (Pl. XXII, *e*) and female flowers (Pl. XXIV, *a*) are borne on separate trees. The berries mature in the autumn of the second year and are spherical or elongated in shape. The firm, hard, purplish-brown skin is covered with whitish bloom, and distinctly marked by the turned-back points of the united female flower scales (Pl. XXII). Sometimes the surface is also marked with small knobs of irregular shape. The berries vary in diameter or in length from about three-eighths to five-eighths of an inch, the largest fruit being produced by trees in shaded situations, and the smallest in dry exposed places. A striking character of the berries is the several-tiered arrangement of the 6 (rarely 4) to 12 irregularly shaped seeds (Pl. XXII, *a*, *b*, *c*, *d*), of which only a few, or sometimes none, are fully developed. The flesh of the berries is hard, dry, and only slightly resinous. The seed-leaves are pointed, two in number, and about one-half of an inch long.

The wood of drooping juniper is a clear yellowish-brown, with a rather thick layer of nearly white sapwood. It is moderately hard and heavy, straight-grained, and very narrow-ringed. Freshly cut wood has a strong cedar odor. Seasoned heartwood is very durable, and has been extensively used locally for mine timbers and to a limited extent for fence posts. Cattlemen and miners familiar with the Chisos Mountains assert that 40 or 50 years ago this juniper was much more abundant than now, and that large numbers of the best trees were then cut and used in mines near Boquillos, Mexico. The present rather limited occurrence of this species in the United States, however, will prevent further commercial and even local use.

OCCURRENCE AND HABITS.

While in this country the range of drooping juniper is confined to the Chisos Mountains of southwestern Texas, it occurs frequently in all of the canyons there, and stretches up even to the tops of the low divides. It grows alike in the deep, washed, gravelly, and sandy soil of watered canyon bottoms (where it is most abundant and best developed), and on dry, rocky benches, slopes, and ridges, becoming more and more stunted as it ascends to the latter situations. It is usually found at elevations between 6,000 and 7,000 feet, probably not going higher. The limits of vertical range in the Chisos Moun-

tains, however, have not been determined. In its Mexican range drooping juniper is said to grow at elevations between 6,000 and 8,000 feet. In the Chisos Mountains it occurs in small groups or as scattered trees, commonly associated with alligator juniper, Mexican piñon, Texas oak, Mexican mulberry, and Texas madrone. Within its vertical range are found Rocky Mountain scrub oak, Emory oak, western yellow pine, one-seed juniper, stunted Douglas fir, Arizona cypress, and Texas ash.

Drooping juniper bears fruit abundantly, especially when growing on open slopes. Some berries are produced practically every year, and especially large crops are borne at intervals of from two to three years. Reproduction is sparse on dry, rocky slopes, but abundant in moist canyon bottoms and on deep-soiled benches. The seed is probably not disseminated to any extent by birds, as in the case of some of the other junipers, because the berries are dry and unpalatable. The relatively small number of perfect seeds in each berry also account for the slow reproduction of this tree.

Seedlings and young trees grow thriftily in dense shade. Pole-size trees can maintain themselves almost indefinitely under such conditions, though their growth is exceedingly slow. The crowns of shaded trees are much thinner and the foliage less robust than in the case of trees enjoying full light. Dense side shade and moderate top light produce the tallest and clearest trunks, with open crowns. Full sunlight gives short trees, with little or no clear trunk and very dense crowns.

LONGEVITY.

Drooping juniper gives evidence of being a very long-lived tree. So far, however, it has been possible for the writer to determine the age of only one tree, 5 inches in diameter at the collar, which was approximately 200 years old. During the first 150 years of its life, this tree appears to have grown in dense shade. During the last 50 years its crown seems to have received direct light, and in this period its growth nearly equaled that of the previous century and a half. The largest trees (from 14 to 20 inches in diameter) so far found in the Chisos Mountains are growing under somewhat more favorable conditions of light, so that they are probably between 400 and 500 years old.

KEY TO SPECIES OF JUNIPERUS.

Trunk bark divided into squarish plates ..... *Juniperus pachyphlœa.*
Trunk bark longitudinally furrowed and ridged:
Leaves minute, scalelike, closely pressed upon twigs:
Branchlets drooping[1] ..... *Juniperus flaccida.*
Branchlets not drooping:
Heartwood purplish or rose-red ..... *Juniperus scopulorum.*
Heartwood yellowish-brown:
Berries large, mostly over one-fourth of an inch in diameter and bluish:
One-seeded:
Seeds round-pointed, furrowed, and creased from top to bottom ..... *Juniperus utahensis.*[2]
Seeds usually chisel-pointed, furrowed only at bottom. *Juniperus megalocarpa.*
Several-seeded ..... *Juniperus occidentalis.*
Berries small, mostly less than one-fourth of an inch in diameter, and bluish or copper-colored:
One-seeded ..... *Juniperus monosperma.*
Several-seeded ..... *Juniperus sabinoides.*
Leaves needlelike, spreading or standing out loosely on the twigs. *Juniperus communis.*

[1] The rare "weeping" form of *J. scopulorum* may be easily distinguished from *J. flaccida* by its rose-red heartwood and small bluish berries.

[2] See *J. knightii*, p. 26.

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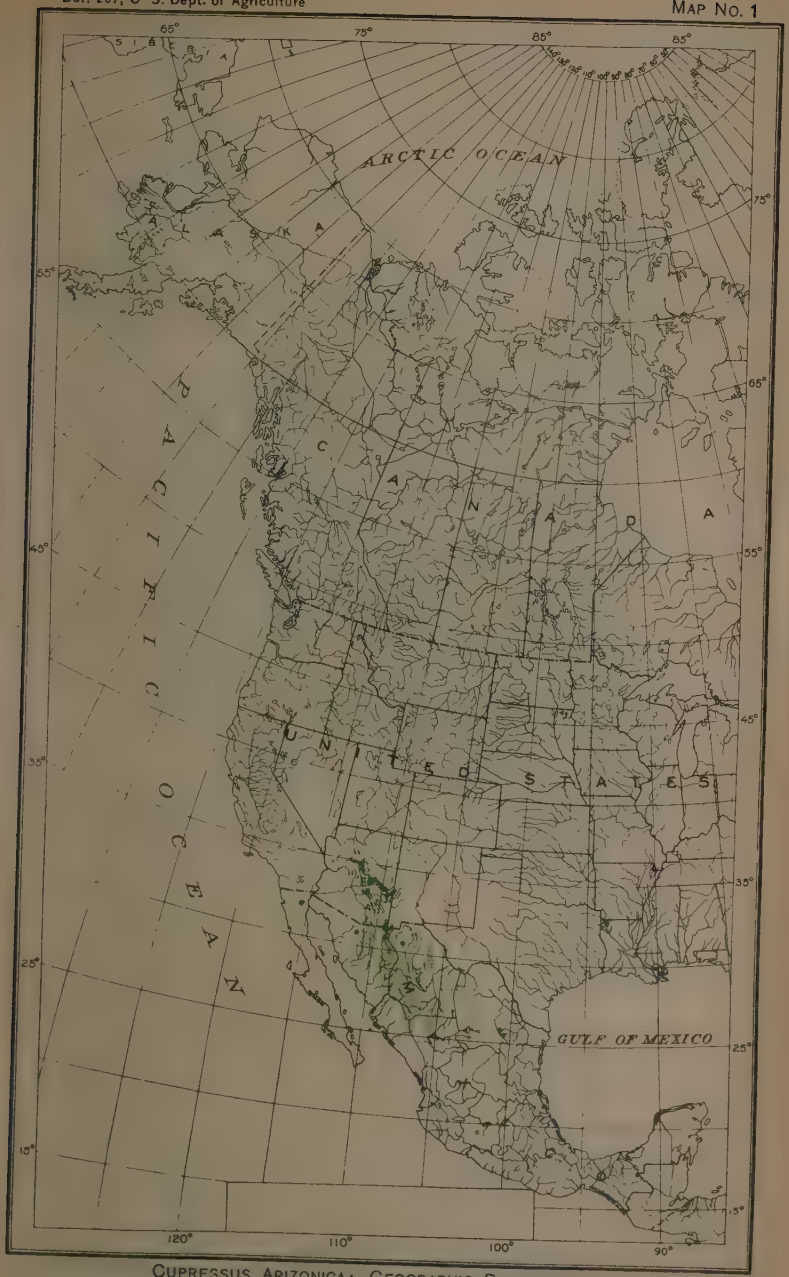

CUPRESSUS ARIZONICA: GEOGRAPHIC DISTRIBUTION.

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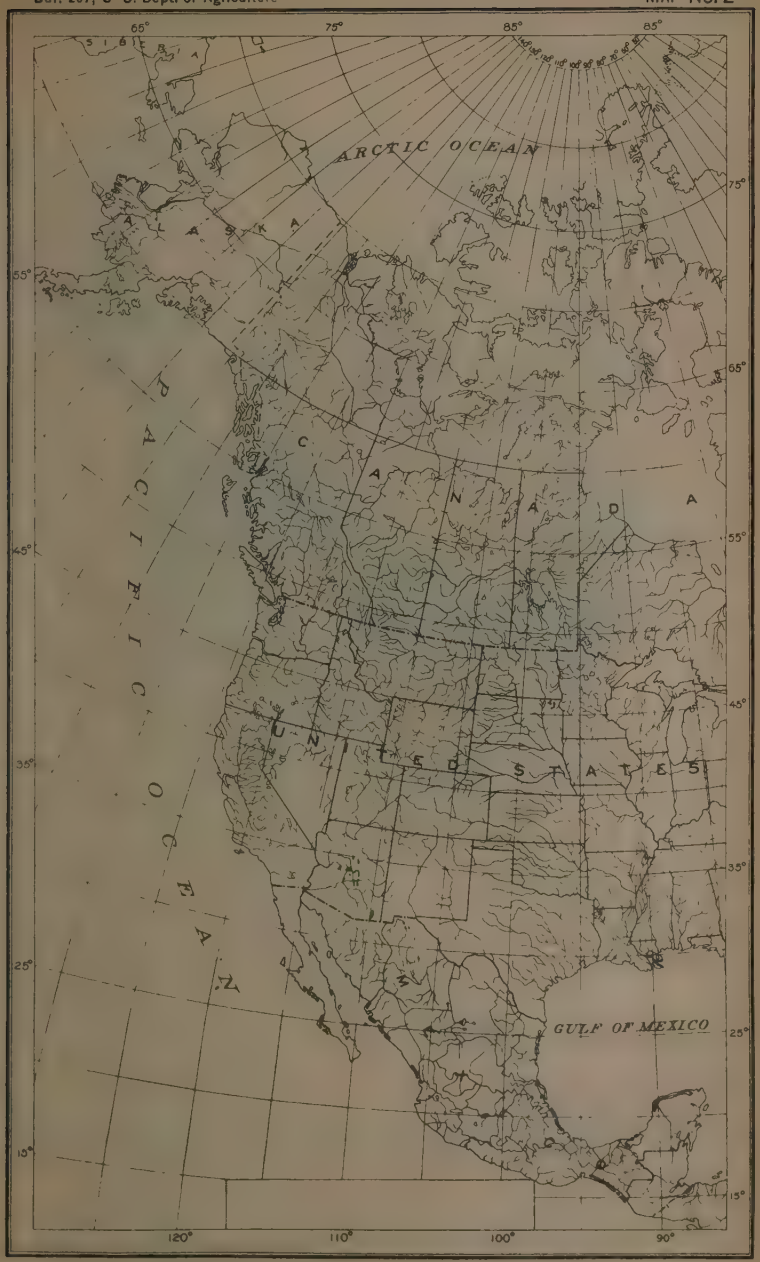
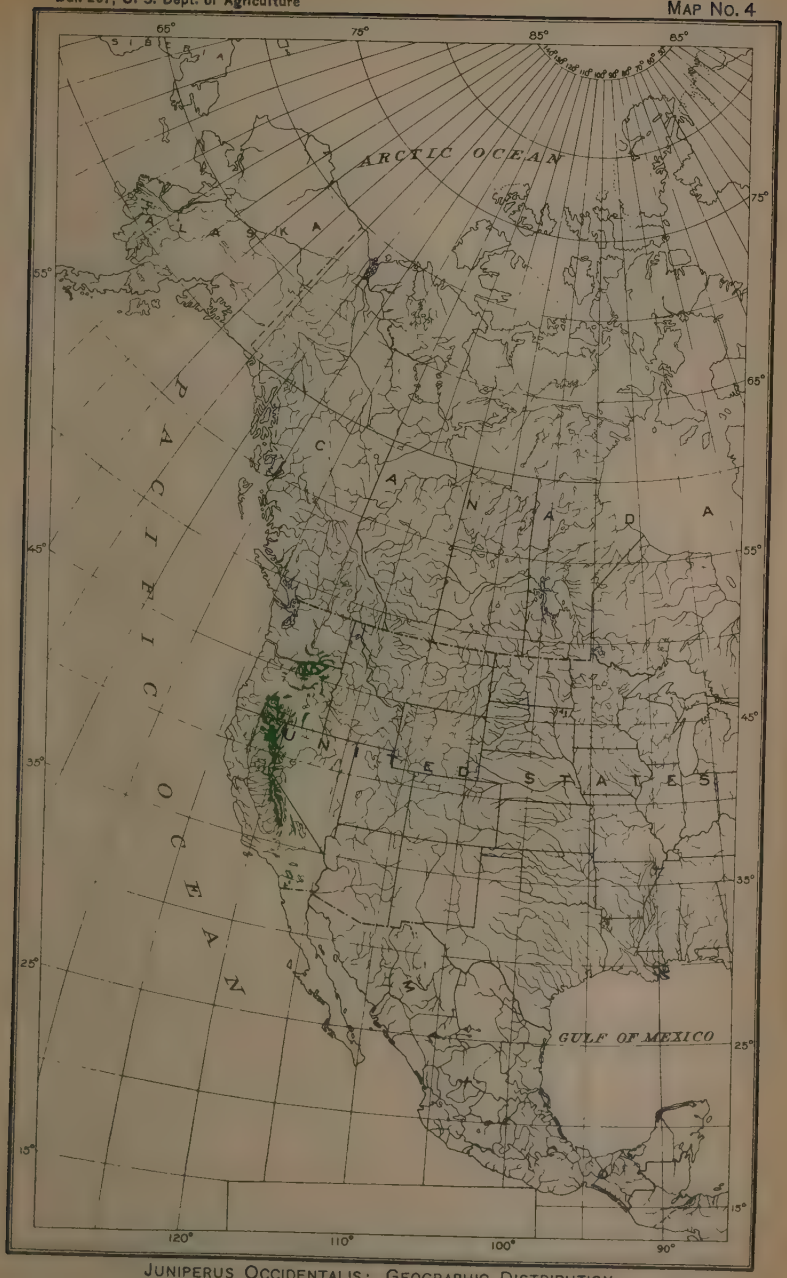


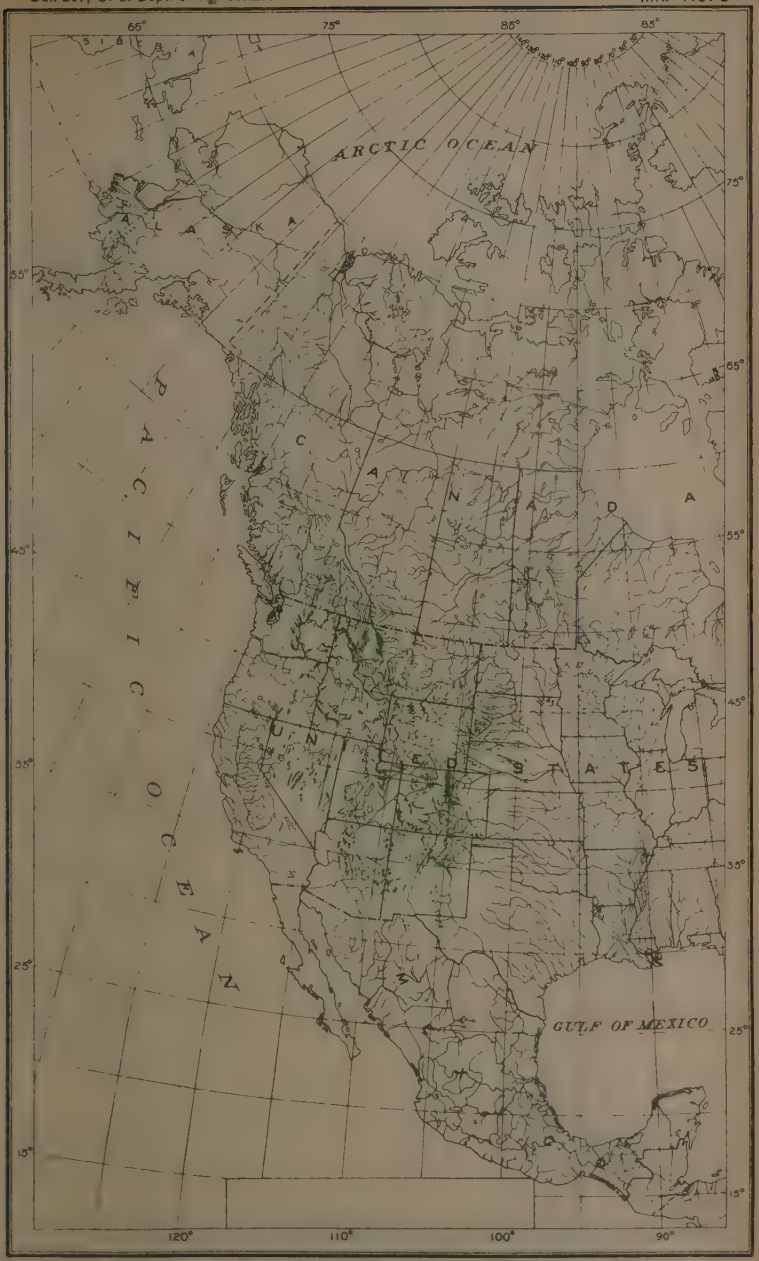
CUPRESSUS GLABRA: GEOGRAPHIC DISTRIBUTION.

MAP NO. 3

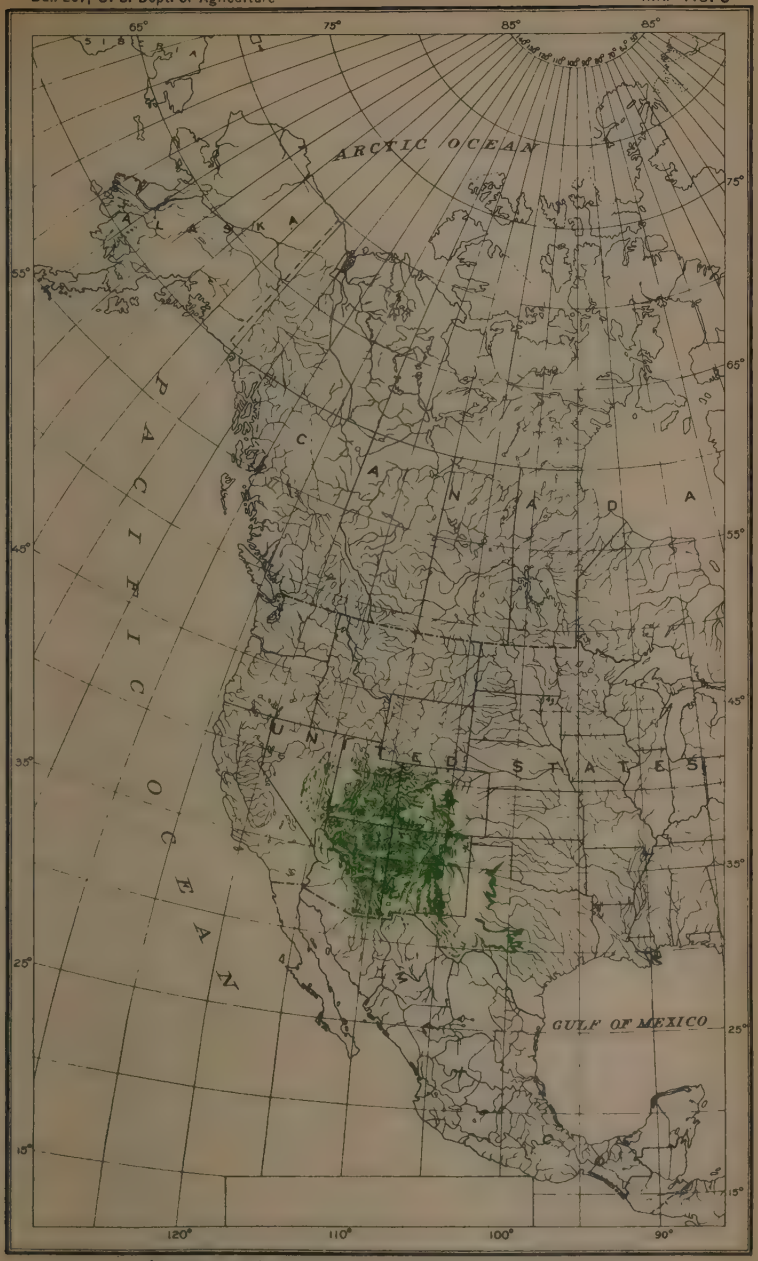
JUNIPERUS COMMUNIS: GEOGRAPHIC DISTRIBUTION.



JUNIPERUS OCCIDENTALIS: GEOGRAPHIC DISTRIBUTION.



JUNIPERUS SCOPULORUM: GEOGRAPHIC DISTRIBUTION.



JUNIPERUS MONOSPERMA: GEOGRAPHIC DISTRIBUTION.

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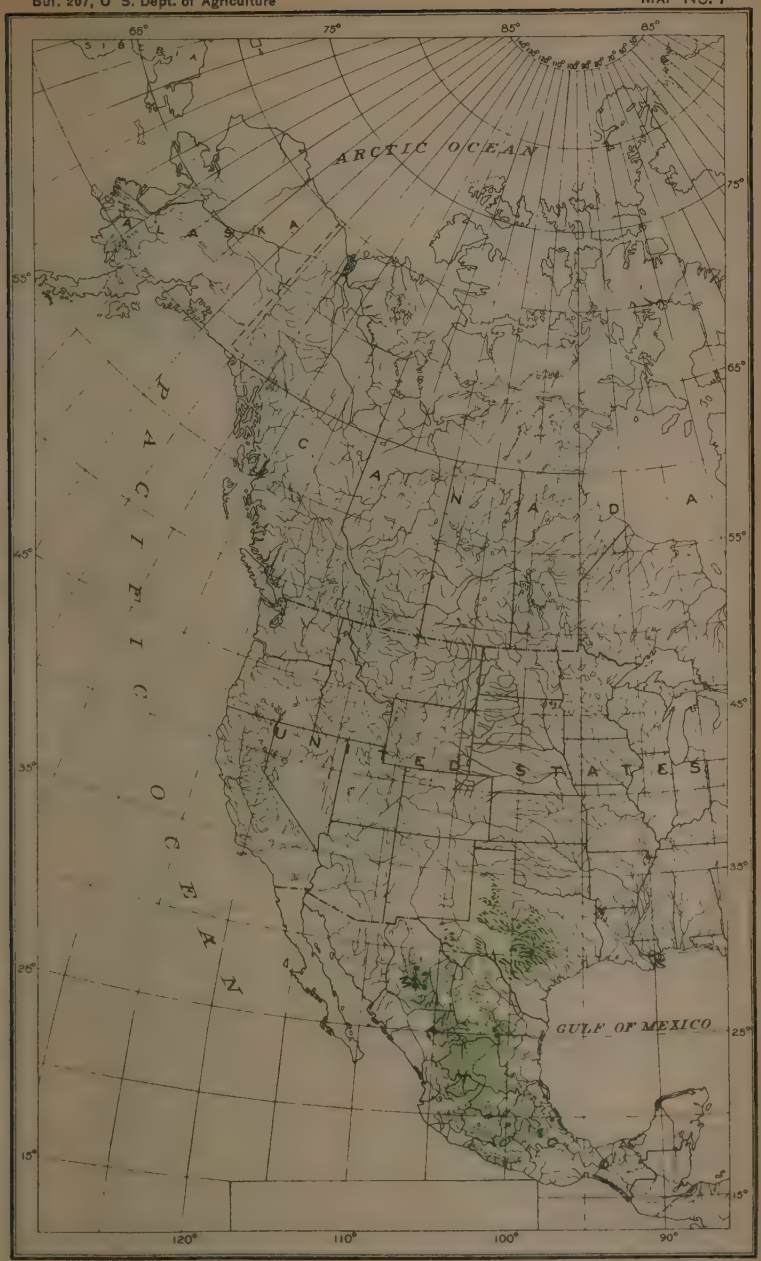

JUNIPERUS SABINOIDES: GEOGRAPHIC DISTRIBUTION.

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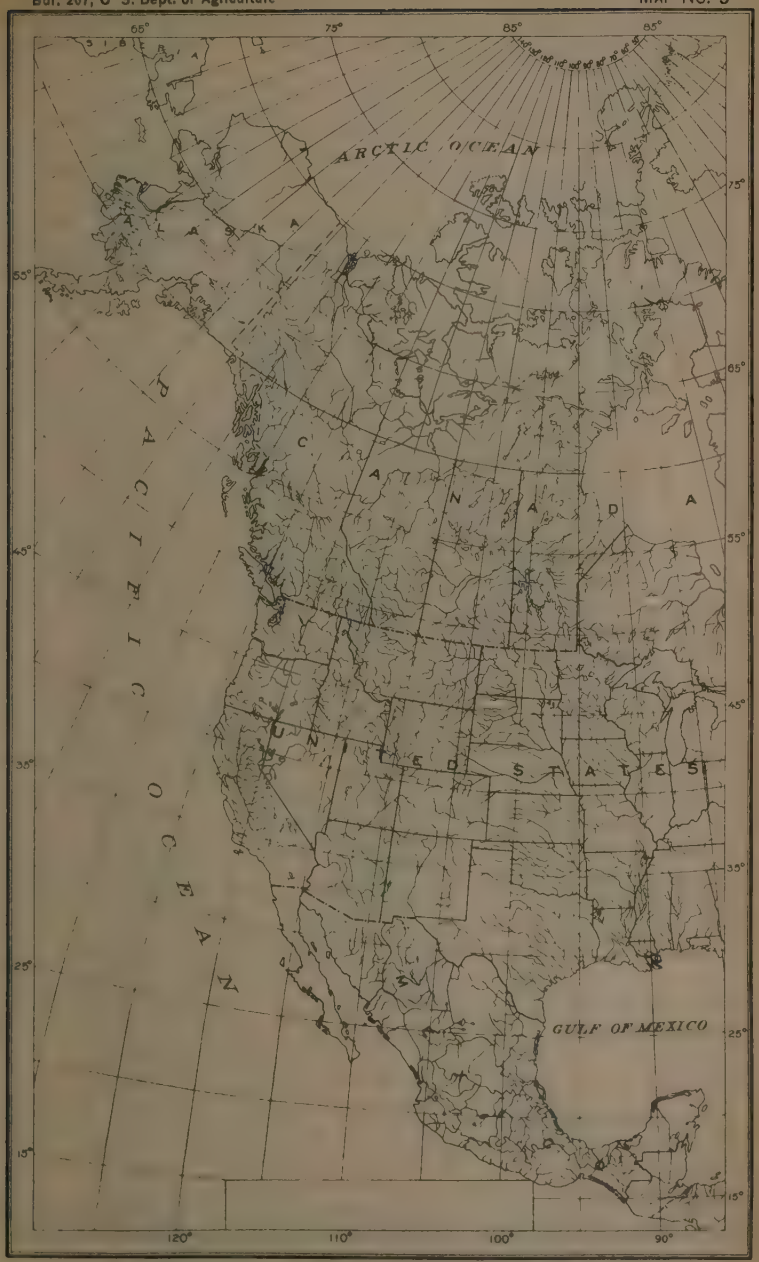
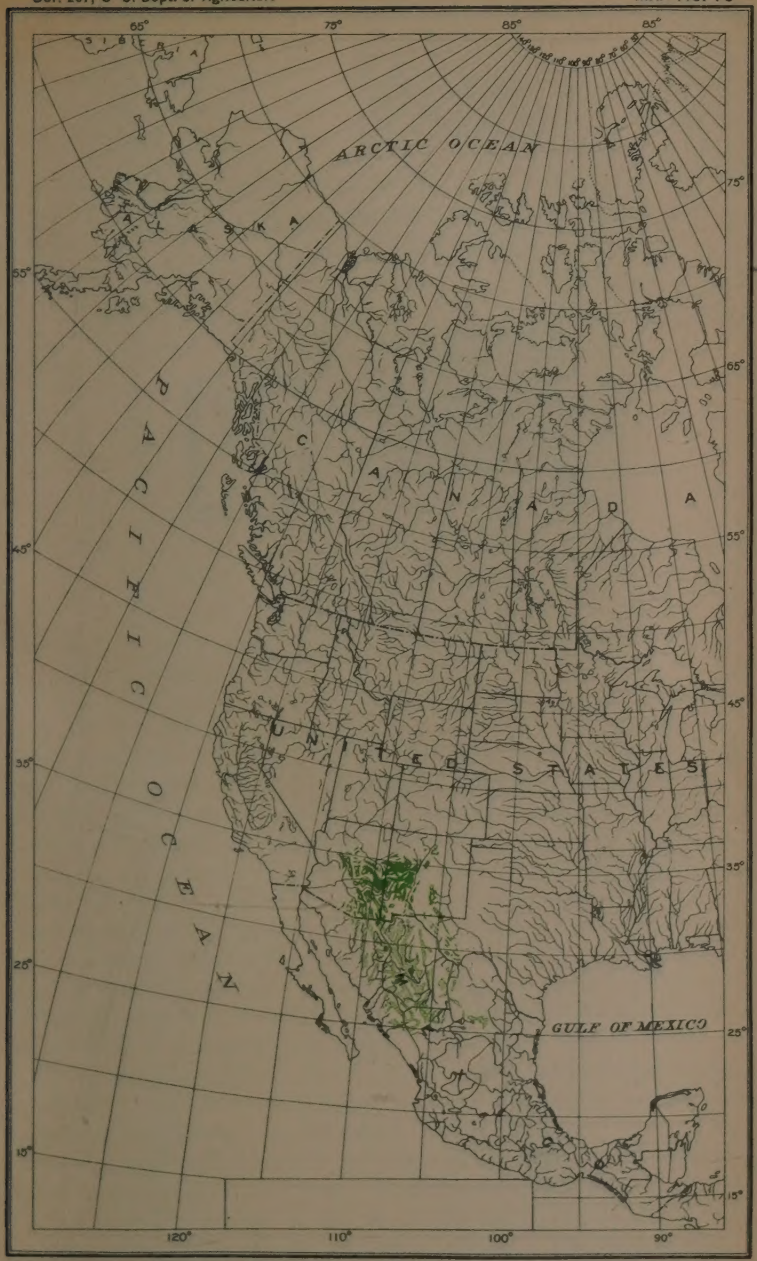
JUNIPERUS UTAHENSIS: GEOGRAPHIC DISTRIBUTION.



JUNIPERUS MEGALOCARPA: GEOGRAPHIC DISTRIBUTION.



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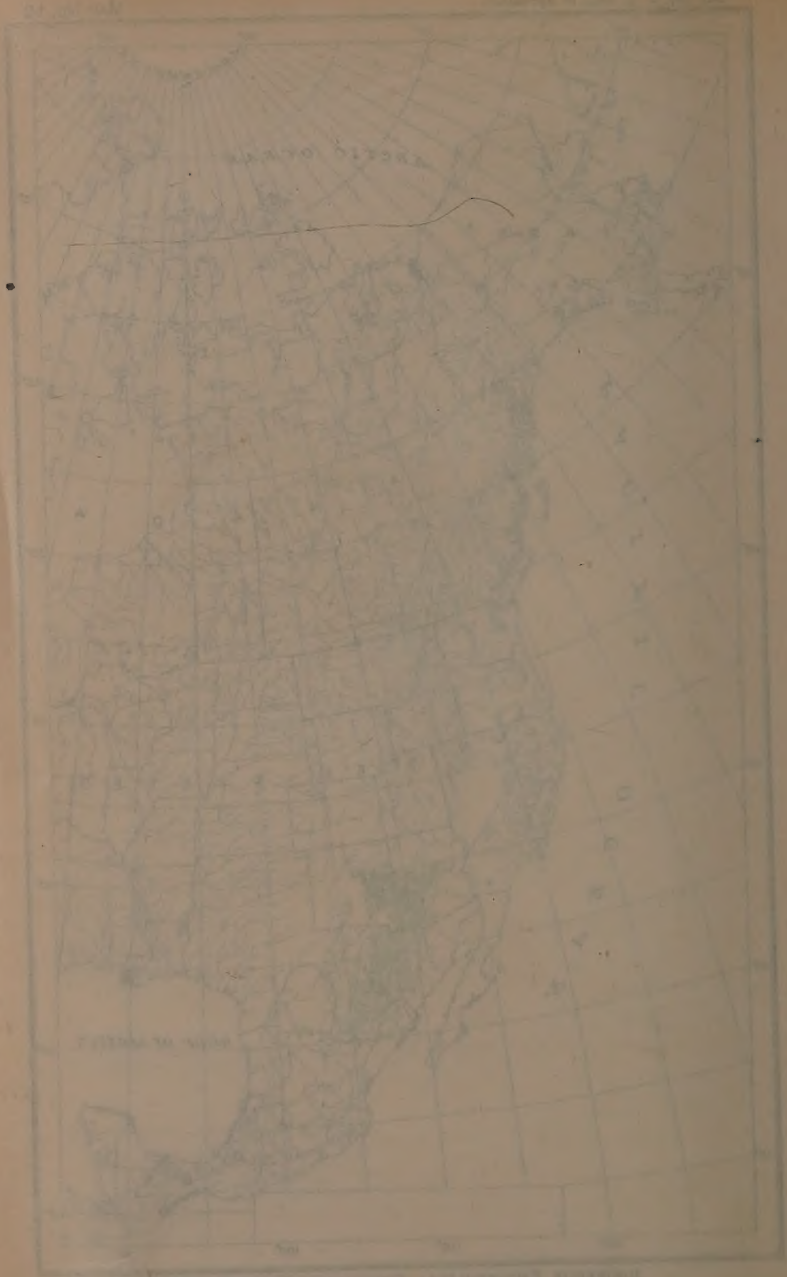

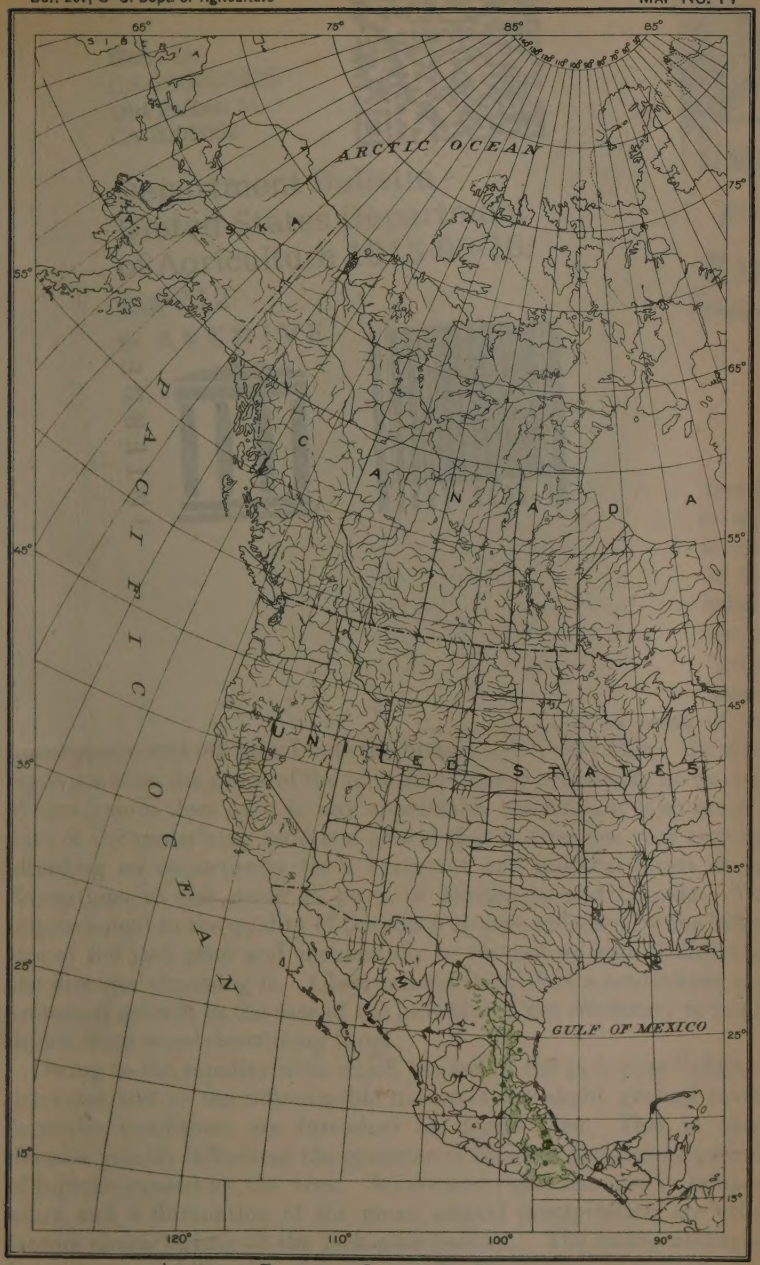

JUNIPERUS FLACCIDA: GEOGRAPHIC DISTRIBUTION.

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